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Support Document/Voluntary Environmental Impact Statement for Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use an Regulation Economic Impact Analysis

Versar, Inc.
Springfield, VA

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ENVIRONMENTAL PROTECTION AGENCY
SUPPORT DOCUMENT/
VOLUNTARY ENVIRONMENTAL IMPACT STATEMENT
for
Polychlorinated Biphenyls (PCBs)
Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation (Section 6(e) of TSCA)

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S-i-a

VOLUNTARY ENVIRONMENTAL IMPACT STATEMENT

SUMMARY SHEET

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1. Name of Action. (Check One)
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2. Description of Action.

   This rule implements §6(e) of the Toxic Substances Control Act (TSCA) which prohibits the manufacturing, processing, distribution in commerce, and use (unless the use is totally enclosed) of PCBs and requires regulations controlling marking and disposal of PCBs. It applies to any chemical substance or combination of substances that contain 50 ppm, or greater, PCB. The rule authorizes several limited exceptions to these general prohibitions in instances where activities do not present an unreasonable risk of injury to health and the environment. These exceptions are related to limited servicing and use activities involving the following: electrical transformers, railroad transformers, hydraulic systems, mining machinery, heat transfer systems, pigments, electromagnets, natural gas pipeline compressors, small quantities for research and development, microscopy, and carbonless copy paper. The use of PCBs has been extensive throughout the United States and, therefore, the rule has a nationwide impact.

3. Summary of Environmental Impact and Adverse Environmental Effects.

   PCBs are a significant environmental pollutant occurring throughout the biosphere. They pose a significant risk to the health of man and numerous other living things. A number of adverse effects on living organisms have been demonstrated, including, but not limited to bioaccumulation, biomagnification, carcinogenicity, mutagenicity, teratogenicity, and fetotoxicity. PCBs are extremely persistent in the environment, circulating among the air, water, and land; and any additional release of PCBs in the environment will eventually result in widespread distribution of PCBs and, therefore, increase exposure and risks.

4. Alternatives Considered.

In developing these proposed rules, EPA considered whether there were other regulatory or nonregulatory options available as alternative approaches to implementing the §6(e) prohibitions against PCB activities and otherwise satisfy the purposes of §6(e) of TSCA. Below is a discussion of the three major options that the Agency considered.

a. No Action.

This alternative was rejected because Congress mandated in TSCA that the manufacturing, processing, distribution in commerce, and use of PCBs be prohibited according to a certain schedule. EPA's discretion with respect to these prohibitions is to establish and clarify certain definitions and to provide exceptions to the prohibitions if there is no unreasonable risk to health and the environment.

b. Action Through Other Statutes or Regulatory Bodies.

This alternative was rejected. It was determined that using other statutes administered by EPA (i.e., Clean Air Act, Clean Water Act, Safe Drinking Water Act, or Resource Conservation and Recovery Act) was inappropriate because they could not provide the comprehensive coverage necessary to implement §6(e). This is also true of statutes administered by other regulatory agencies or state governments. Furthermore, there is a strong case that EPA is required by TSCA to use §6(e) of TSCA to implement and grant exceptions, if appropriate, to the explicit prohibitions mandated by §6(e). Section6(e)(4) specifically exempts EPA from the requirements of §6(c)(1), including that of considering the use of other EPA-administered authorities as alternatives to rulemaking under §6 of TSCA. This indicates that Congress intended that EPA use TSCA to implement these prohibitions on PCBs.

The use of other authorities to resolve the PCB problem addressed by §6(e)(2) and (3) would be impractical, complex, time consuming, and in some cases impossible. No other Federal statute grants the kind of authority necessary to directly control the range of PCB activities covered by §6(e). Sections of several statutes might have to be invoked in separate actions for each aspect of each PCB activity. A number of indirect controls would be necessary to effectively prohibit PCB activities as required by TSCA except in those cases where risks were found to be reasonable.

The other relevant statutes, moreover, are often not designed to provide this comprehensive coverage, even when used in concert. For example, many sources of PCB air emissions are not included within the definition of sources subject to regulation under the Clean Air Act (CAA). The concepts of area-wide standards and controls in the Clean Water Act (CWA) and the CAA do not seem appropriate for implementing these prohibitions of PCBs and specific PCB Articles or activities of concern. There are final regulations under §307(a) of the CWA which complement this regulation and which set effluent standards prohibiting any discharge of PCBs, but only from PCB manufacturers, electrical capacitor manufacturers, and electrical transformer manufacturers. If the CWA, the Safe Drinking Water Act, or the Resource Conservation and Recovery Act were used in lieu of TSCA, many spills could be controlled, but other aspects of the PCB problem could not.

Some other Federal statutes not administered by EPA could also be utilized to control some types of exposure to PCBs. The National Institute for Occupational Safety and Health has set a workplace exposure criterion of 5 ppm for employee exposure and recommended that the Occupational Safety and Health Administration prepare regulations accordingly. But again, this only addresses a part of the problem. A few States have regulations on PCBs, but they are not sufficient to cover all activities addressed by TSCA nor, obviously, do they provide control of PCBs on a national scale.

c. Action Under Section 6(e) of TSCA.

Numerous alternatives were considered within the authority of §6(e) of TSCA. These alternatives were fully discussed in the Support Document/Voluntary Draft Environmental Impact Statement, the Preamble to proposed regulation, and the Preamble to this regulation.

5. Major Definitions.

"PCB" is defined to mean any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances which contains such substances.

"Significant Exposure" is defined as any exposure of human beings or the environment to PCBs, as measured or detected by any scientifically acceptable analytical method.

6. Totally Enclosed Activities.

Congress mandated in §6(e)(2) of TSCA that all non-totally enclosed activities are banned as of January 1, 1978. Non-totally enclosed was defined by Congress to mean any manner that resulted in significant exposure as specified by EPA. Below are identified those activities that the Agency considers to be totally enclosed.

PCB Transformers (non-railroad) - Use, except servicing, of intact, non-leaking PCB transformers is considered totally enclosed.

PCB-Contaminated Transformers - Use, except servicing, of intact, non-leaking PCB-contaminated transformers is considered totally enclosed.

Electromagnets - Use, except servicing, of intact, non-leaking electromagnets is considered totally enclosed.

PCB Capacitors - Distribution and use of intact, non-leaking, PCB Capacitors are considered totally enclosed.

PCB Equipment - Processing, distribution in commerce, and use of PCB Equipment are considered totally enclosed.

7. Authorizations.

The Agency has found that the following activities do not present an unreasonble risk to health and the environment. In making these decisions the Agency considered (1) the health and environmental effects of PCBs, (2) the exposure to PCBs from these activities, (3) the availability of substitutes in these uses, and (4) the economic impact from restricting these uses. Unless otherwise noted, all authorizations expire on July 1, 1984; however, exemptions must be obtained if processing and distribution in commerce are to continue after July 1, 1979.

PCB Transformers (non-railroad) - Processing, distribution in commerce, and use are authorized. Servicing (except rebuilding) is authorized.

PCB-Contaminated Transformers - Processing, distribution in commerce, and use are authorized. Servicing (including rebuilding) is authorized.

Railroad Transformers - Processing, distribution in commerce, and use are authorized. Servicing (including rebuilding) is authorized.

Mining Equipment - Processing, distribution in commerce, and use (including servicing) are authorized until 1/1/82. After 1/1/80, rebuilding of continuous miner type motors is prohibited.

Heat Transfer Systems - Use is authorized.

Hydraulic Systems - Processing, distribution in commerce, and use are authorized.

Pigments - Processing and distribution in commerce are authorized. Use is authorized until 1/1/82.

Electromagnets - Processing, distribution in commerce, and use are authorized. Servicing (except rebuilding) is authorized.

Natural Gas Pipeline Compressors - Use is authorized until 5/1/80.

Small Quantities for Research and Development - Processing, distribution in commerce, and use are authorized.

Microscopy - Processing, distribution in commerce, and use are authorized.

Carbonless Copy Paper - Use is authorized indefinitely.

8. Federal Agencies That Participated on EPA's PCB Work Group:

Department of Commerce
Department of Defense
Department of Transportation
Department of Interior
Federal Railroad Administration
General Services Administration
National Institute for Occupational Safety and Health
Tennessee Valley Authority

9. On or about April 20, 1979 the Support Document/ Voluntary Environmental Impact Statement was officially filed with the Director, Office of Federal Activities, EPA. It is available to the public. Copies can be obtained by writing the Industry Assistance Office, Office of Toxic Substances (TS-793), Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, or by calling (800) 424-9064, in Washington, D.C., call 554-1404. The official record of rulemaking, including both the draft and final Support Document/Voluntary Environmental Impact Statement, is located in room 709, East Tower, Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, (202) 755-6956. It will be available for viewing and copying from 9 a.m. to 4 p.m., Monday through Friday excluding holidays.

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I. INTRODUCTION

PCBs have been used in the United States since 1929 in such applications as transformer cooling liquids, capacitor dielectric fluids, heat transfer and hydraulic liquids, dye carriers in carbonless copy paper, plasticizers in paints, adhesives, and caulking compounds, fillers in investment casting wax, and dust control agents in road construction.

Monsanto was the major U.S. manufacturer of PCBs. Since 1972, Monsanto limited sales of PCBs to manufacturers of transformers and capacitors. Monsanto ceased manufacturing PCBs in mid-1977, and shipped the last remaining inventory by October 31, 1977.

Small quantities of PCBs may be produced currently, as unintentional byproducts of other chemical processes. Similarly, chlorination of water which contains appreciable concentrations of biphenyl can result in the unintentional formation of PCBs. No natural sources of PCBs have been identified.

Prior to the enactment of the Toxic Substances Control Act (TSCA), the authority of the EPA with respect to PCBs was limited to the regulation of contaminated water from point sources. EPA promulgated a rule under Section 307(a) of the Clean Water Act on February 2, 1977 (42 FR 6532-6556), which banned the discharge of PCBs into navigable waters by electrical transformer and capacitor manufacturers.

The enactment of TSCA in October 1976, placed additional restrictions on the use of PCBs and required that certain actions be taken by EPA. Section 6(e)(1) of TSCA required that EPA promulgate a disposal and marking rule for PCBs. This rule, promulgated by EPA on February 17, 1978 (43 FR 7150-7164), regulates the disposal of PCBs and requires that special warning labels be applied to large capacitors, transformers, and other PCB Items. The Disposal and Marking Rule covered liquid PCBs and all other material and equipment components containing or having contained PCBs in concentrations of greater than 500 ppm (0.050 percent). Clarifying amendments to this rule were published on August 2, 1978 (43 FR 33918).

On June 7, 1978 EPA published the proposed rules (43 FR 24802) implementing §§6(e)(2) and 6(e)(3) of TSCA. These rules proposed to prohibit or authorize certain PCB activities that are not conducted in a totally enclosed manner. This rule also specified those activities that the Agency considered to be performed in a totally enclosed manner.

Concurrently with the proposed rule, the Agency also published a Support Document/Voluntary Draft Environmental Impact Statement (Draft Support Document). In that document, the Agency discussed the different alternatives it considered in regulating the various PCB activities.

The Agency held 10 days of public hearings in Washington, D.C. from August 21 to September 1 to solicit comments on the proposed rule. Over 50 oral presentations were made. On September 22, 1978 (43 FR 43048), EPA published a notice of the opportunity for cross-examination and extended the reply comment period to October 10, 1978. Two hearing participants conducted cross-examination on September 26, 1978. EPA received over 200 comments on the proposed rule.

Section 6(e)(3)(B) of TSCA also provides that persons may petition the Administrator for exemptions from the prohibition of the manufacture, processing, and distribution in commerce of PCBs or PCB Items. Interim rules establishing procedures for submitting petitions for exemptions from the prohibitions were published on November 1, 1978 (43 FR 50905). More than 70 petitions for exemptions have been received. On January 2, 1979 EPA announced (44 FR 108) that it would not enforce the PCB manufacturing and importation ban of §6(e)(3)(A) against persons who submitted petitions, until EPA had acted on their request for exemptions.

Concurrently with publication of the final manufacturing, processing, distribution in commerce, and use bans, the Agency has published its proposed disposition on the requests for exemptions from this Rule. Public hearing and publication of the final disposition will be forthcoming.

This Support Document/Voluntary Environmental Impact Statement (Final Support Document) has been prepared to address the major comments made during the rulemaking proceedings. Each of the major comments has been listed and assigned a number in parentheses in Appendix I to this document. For the convenience of readers, representative comments are referenced by number when they are addressed by the Agency in this document. EPA wishes to emphasize, however, that the comments listed may not represent all of the comments considered by EPA and which address the particular issue discussed. In some cases, discussion of issues raised by commentors will also be found in the Preamble to the final rule.

As noted, this document responds to comments received on the proposed rule. It contrasts with the Draft Support Document which discussed the options the Agency considered to control the various applications of PCBs. Two sections (Section I, Background and Section II, Alternatives to this Rule) in the Draft Support Document that are relevant to this phase of rulemaking have been revised and included in this Support Document in the Introduction and the Summary Sheet. Section III (Significance of Release of PCBs Into the Environment), and Section V (Substitutes) of the Draft Support Document are included as Sections II and III of this Final Support Document. Minor revisions have been made in these sections prior to their inclusion. The three remaining sections, Section IV (Definition of PCB Mixture), Section VI (Reasonable use Determinations), and Section VII (Waste Oil), although containing much of the same rationale used in the final rulemaking, have not been included in this document. However, those three sections describe (1) the regulatory options considered by EPA prior to proposal of this rule and (2) reflect the information that was then available to the Agency.

This Support Document/Voluntary Environmental Impact Statement contains the same information as would be prepared to meet the requirements of Section 6(c)(1) of TSCA. While not legally required to prepare an Environmental Impact Statement (EIS) by Section 102(2)(c) of the National Environmental Policy Act (NEPA) of 1969, EPA has voluntarily prepared this Support Document/Voluntary Environmental

Impact Statement in conformance with the spirit of its 1974 statement on voluntary EIS's (39 FR 37419, October 21, 1974). The voluntary preparation of this document in no way legally subjects the Agency to NEPA requirements.

Persons who are interested in the approximate costs to the various industries to comply with the requirements of the rule, are referred to the economic study entitled PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation: Economic Impact Analysis (the Versar Report) found at the end of this document.

EPA wishes to emphasize that equality of PCB regulatory costs for the different affected industries described in the economic study is not the goal of this regulation. EPA is seeking to regulate as many PCBs as possible. The Agency recognizes, however, its inability to regulate some activities, such as disposal of many types of PCB Equipment, due to the broad ownership of such equipment at a vast number of sites. Although equality of regulatory costs for different affected industries has not been a goal, EPA has, where appropriate, taken costs into account by lengthening the compliance schedule or allowing disposal alternatives.

II. SIGNIFICANCE OF THE RELEASE OF PCBs INTO THE ENVIRONMENT

Introduction

Section 6(e)(2)(A) of TSCA prohibits the manufacture, processing, distribution in commerce, and use of PCBs after January 1, 1978, in other than a totally enclosed manner. "Totally Enclosed Manner" is defined by TSCA to mean a manner which will ensure no significant exposure of human beings or the environment to PCBs, as determined by EPA by rule [Section 6(e)(2)(C)]. The final rule, in turn, provides that human or environmental exposure to any detectable quantities of PCBs shall be deemed significant. This provision is based on the finding that any release of PCBs into the environment will eventually result in widespread exposure of wildlife, including some of man's major food sources, and humans and that any such exposure may have adverse effects.

The following sections summarize the variety of adverse effects which PCBs have been found to have in humans, laboratory animals, and other organisms, and the extent to which PCBs released into the environment become distributed throughout the biosphere. The adverse effects have been described in greater detail in various documents, including EPA Report No. 440/9-77-021, Criteria Document for PCBs, July 1976; Criteria for a Recommended Standard: Occupational Exposure to Polychlorinated Biphenyls (PCBs), National Institute for Occupational Safety and Health, September 1977; and "Environmental Health Criteria: Polychlorinated Biphenyls and Polychlorinated Terphenyls," World Health Organization, 1976. PCB-induced effects were also reviewed in detail in expert testimony at a public hearing before EPA and were acknowledged and described in a decision by the Administrator to promulgate toxic pollutant water effluent standards for PCBs (42 FR 6532-6556, February 2, 1977). These standards were affirmed in Environmental Defense Fund vs. Environmental Protection Agency, 12 E.R.C. 1353 (D.C. Cir. 1978).

Significance of Exposure to PCBs

A. Absorption and Storage

PCBs are absorbed through the lungs, the gastrointestinal tract, and the skin.[1] After absorption, PCBs are circulated throughout the body in the blood and are stored in adipose tissue and in a variety of organs and tissues, including the liver, kidneys, lungs, adrenal glands, brain, heart, and skin.[2]

B. Specific Adverse Health Effects of PCBs as Observed in Toxicology Tests and Epidemiological Studies

The view that human health risks resulting from exposure to chemicals may be determined experimentally by testing laboratory animals is one that is widely accepted in the scientific community and has been adopted by EPA. Because experimentation on human beings raises ethical questions and because epidemiological studies often provide incomplete information, toxicology studies on laboratory animals are often necessary. However, because the extrapolation from animals to man is subject to some uncertainty, corroboration of laboratory test data with sound epidemiological information is desirable. The available toxicological and epidemiological data relating to the effects of PCBs are discussed below.

1. Oncogenicity

PCBs appear to have caused malignant and benign tumors in rats and mice in several experiments.[3] In one carefully conducted experiment, rats fed 100 ppm of Aroclor 1260 in the diet for 21 months developed a high incidence of carcinomas (26/184) and neoplastic nodules (144/184) in the liver. Only one of 173 control animals developed a carcinoma, and none developed neoplastic nodules. In another experiment, rats were fed Aroclors 1242, 1254, and 1260 for 24 months. Rats exposed to any of the three mixtures at 100 ppm in the diet developed liver tumors (hepatomas and cholangiohepatomas), whereas none was observed in the controls (3/20 for Aroclor 1242, 6/27 for Aroclor 1254, 7/27 for Aroclor 1260, and 0/20 for the controls). A high frequency of nodular hyperplasia in the liver, considered by some authorities to be precancerous, was observed in the rats fed 100 ppm of the three mixtures. A significant increase in frequency in comparison to controls was observed down to the 10 ppm dosage level.[4]

The results of the epidemiological data, although somewhat ambiguous, provide additional evidence that PCBs pose a carcinogenic risk to man. In 1968, at least 1,291 persons were afflicted with a disease known as Yusho as a consequence of eating rice oil contaminated with PCBs and relatively smaller amounts of polychlorinated dibenofurans (PCDFs). Although precise data are not yet available, a preliminary tabulation of the deaths among Yusho victims through 1975 showed an excess in the rate of cancer, particulary of the stomach and liver.[5] In another preliminary study, 92 workers considered likely to have been exposed to Aroclor 1254 at a New Jersey petrochemical facility between 1949 and 1957 indicated a significant excess of malignant melanoma and pancreatic cancer.[5a] In the third study, an examination of the death certificates of 50 employees formerly engaged in the manufacture of PCBs revealed seven cases of lung cancer, compared with an expected 2.5 cases. However, these results were not corrected for age or smoking habits and are only preliminary.[6]

2. Teratogenic, Fetotoxic, and Reproductive Effects

Beagle dogs fed Aroclor 1254 at the rate of 1.0 mg/kg/day had offspring with a significantly higher incidence of patent fontanelles than did controls but exhibited no decrease in the number of offspring. In the same experiment, dogs fed 5.0 mg/kg/day had a fetal resorption rate of 45.5 percent (a fourfold increase over controls). Patent fontanelles were present in 50 percent of the offspring.[7]

Sows fed Aroclor 1254 at a dose of 1.0 mg/kg/day for 21 days before breeding and throughout gestation experienced a statistically significant rate of fetal resorption. Higher dosages further reduced fertility and caused a variety of defects in the offspring, including cleft palate, syndactyly, and patent fontanelles.[8]

Female rhesus monkey fed PCBs at 5 ppm and 2.5 ppm in the diet for 6 months before mating with untreated males demonstrated severe reproductive dysfunctions. Only one of the eight animals fed the higher dose gave birth, with five animals experiencing abortions and two not conceiving at all. Of the eight monkeys fed the lower dosage, five gave birth to extremely small infants, and three aborted.[9]

In another experiment, three of six infant rhesus monkeys born to mothers fed 2.5 ppm of PCB died within 6 months of birth. The surviving three infants exhibited behavioral and learning defects.[10]

Studies with mink have also demonstrated the adverse effects of PCBs on reproduction. Ranch mink fed coho salmon contaminated with 12 to 20 ppm of PCBs suffered reproductive failure and kit mortality. Female mink fed dosages as low as 5 ppm of Aroclor 1254 and 2 ppm of Aroclor 1016 experienced substantial reductions in the number of live kits born.[11]

3. Enzyme Induction by PCBs

It has been demonstrated in several experiments that PCBs induce various microsomal enzymes of the liver, including mixed-function oxidases. Such induction has occurred after administration of Aroclors 1016, 1242, 1248, 1254, and 1260 to rats at dosages as low as 1 mg/kg/day for 21-28 days in the diet. Some of the enzymes induced by PCB mixtures and chlorobiphenyl isomers in rats and other animals are nitroreductases, dimethylases, diethylases, glucose-6-phosphatases, aryl hydrocarbon hydroxylases, cytochromes P-450 and P-448, NADPH cytochrome reductases, and delta-aminolevulinic acid synthetases.[12] In one study it was shown that humans exposed to PCBs showed elevated levels in the blood of the enzyme, gamma glutamyl transpeptidase, a sensitive indicator of liver dysfunction.[13]

The consequences of this enzyme induction may be quite significant. Some of the enzymes induced by PCBs, such as cytochrome P-450 and cytochrome P-450 dependent N-demethylase, are involved in the metabolism of therapeutic drugs. Induction of these enzymes would therefore be expected to alter the function of such drugs and interfere with the treatment of diseases in humans. This possibility has been clearly demonstrated in one experiment in which workers occupationally exposed to Aroclor 1016 for the 2 years immediately before the experiment and to Aroclors 1242, 1254, and 1260 in earlier years were administered antipyrine, a prototype drug substrate. The half-life of the antipyrine in the plasma of the exposed workers was approximately two-thirds of that observed in control subjects.[14]

Another expected consequence of the induction of certain liver enzymes is an alteration of the incidence of human cancer. Although the mixed-function oxidases detoxify foreign chemicals in the body, they may also metabolize some of these substances into more toxic or carcinogenic forms.[15] However, it is difficult to predict whether induction of these enzymes would have a net effect of increasing or decreasing the incidence of cancer.

Induction of liver enzymes by PCBs could also result in a modification of the overall metabolism of the body by altering the metabolism of the steroid hormones.[16] In addition, stimulation of the production of the enzyme delta-amino-vulinic acid synthetase by PCBs has been demonstrated to cause porphyria and accumulation of porphyrins in the liver in rats, mice, and rabbits.[17]

4. Effects on the Immunological System

Several experiments have demonstrated that PCB mixtures produce immunosuppressive effects in laboratory animals. In one study, guinea pigs were fed Aroclor 1260 at 10 ppm in the diet for 8 weeks and received injections of tetanus toxoid to stimulate antitoxin production by the lymphoid system. In comparison to controls, PCB-treated animals exhibited reduced numbers of gamma-globulin-containing cells in the lymph nodes as well as reduced serum gamma-globulin levels.[18] Infant rhesus monkeys dosed with 35 mg/kg of Aroclor 1248 for 4 weeks exhibited atrophy of the thymus. The same effect was observed in rhesus monkeys fed daily doses as low as 3 ppm of Aroclor 1242.[19] In addition, decreased weight and atrophy of the thymus and lymphoid system were observed in guinea pigs and rats administered oral doses of PCBs.[20]

5. Mutagenicity

Whydam and co-workers demonstrated that 4-chlorobiphenyl is a potent mutagen in the Ames test for bacterial mutagenesis.[21] These workers also found that the mutagenic activity of PCBs decreased with increasing chlorination and that the most highly chlorinated mixtures had almost no activity.

In several studies, various doses of Aroclor 1242 and Aroclor 1254 were administered to rats and the chromosomes of the bone marrow and testicular cells of these animals were then examined for abnormalities. No significant increases in chromosomal aberrations were observed in comparison with controls. In another study, administration of these chemicals to rats did not appear to induce dominant lethal mutations.[22]

6. Effects on the Liver and Stomach

The induction of hepatic microsomal enzymes and the causing of malignant tumors of the liver by PCBs have already been discussed. Other adverse effects on the liver have also been observed and are described here.

In one study, weaning rats fed Aroclor 1254 at 1 ppm in the diet exhibited significantly increased liver weights.[23] In another experiment, rats fed Aroclors 1248, 1254, and 1260 at 1000 ppm in the diet for 6 weeks were found to have hypertrophied livers weighing four times as much as those controls. Abnormal ultra-structural changes within the liver cells of the PCB-treated animals included proliferation of smooth endoplasmic reticulum, development of large concentric arrays of membranes, atypical mitrochondria, and increases in lipid droplets.[24] One study performed by the National Cancer Institute observed proliferative changes in the liver cells of rats.[25] In guinea pigs, liver damage has been observed at dosages of Clophen A60 (a PCB mixture) as low as 250 ppm in the diet. Increased liver weight has been observed at doses down to 50 ppm.[26]

Low oral doses of PCBs have resulted in stomach lesions in several species. Dogs fed dietary levels of 1 ppm of Aroclors 1254 and 1260 and 10 ppm of Aroclor 1242 for 2 years suffered from stomach ulcers and nodules. Rhesus monkeys fed 2.5 ppm of Aroclor 1248 and 3 ppm of Aroclor 1242 in the diet developed stomach lesions which were severe in some cases. Sows also suffered from stomach lesions after being fed Aroclor 1242.[27]

7. Effects on Skin and Other Epidermal Tissues

Exposure to PCBs has resulted in various adverse effects on the skin and other epidermal tissues in humans. Chloracne, a specific type of acne caused by certain chlorinated hydrocarbon compounds, has developed among workers occupationally exposed to air containing PCBs at levels as low as 0.1 mg/m.[28] Skin lesions similar to chloracne have been one of the major clinical signs observed in victims of Yusho disease. In addition, Yusho victims have experienced eye discharges caused by hypersecretion of the meibomian glands, swelling of the upper eyelids and hyperpigmentation of the skin, nails, and mucous membranes. It has been estimated that Yusho disease has resulted from ingestion of PCBs in contaminated rice oil at a rate as low as 67 ug of PCB/kg of body weight per day for 3 months, although it should be noted that the Yusho incident involved exposure to high concentrations of chlorinated dibenzofurans and other chemicals which make it difficult to develop precise conclusions.[27]

8. Other Effects

Workers exposed to PCBs have been shown to have elevated levels of fat (triglycerides) in the blood.[30] The best current thinking in medicine is that such elevations constitute a serious risk for the development of heart diseases and strokes. Workers exposed to PCBs have experienced numerous other symptoms and adverse effects, including digestive disturbances, jaundice, impotence, dry or sore throat, and headache.[31] In addition, Yusho victims have suffered from abdominal pain, menstrual irregularity, fatigue, cough, and disorders of the peripheral nervous system.[32]

C. Effects on Wildlife

It is reasonble to expect that many of the adverse effects observed in laboratory animals could also occur in wild mammals exposed to PCBs. Since, as discussed below, PCBs have a tendency to collect in waterways and bioaccumulate in fish, fish-eating mammals such as otters, mink, and bears are particularly at risk. It has already been noted that mink fed PCB-contaminated fish suffered reproductive failure. Other effects observed in exposed mink include reduced weight gain, increased mortality, and enlargement of the liver, kidneys, and heart.[33]

Many wild birds are probably also highly susceptile to PCBs. Several fish-eating birds, including two bald eagles, have been found dead with lethal quantities of PCBs in the tissues.[34] Ring doves and American kistrels fed 10 ppm of PCBs suffered from severe reproductive failure. In addition, birds exposed to PCBs have also exhibited induction of hepatic microsomal enzymes, porphyria, changes in thyroid activity, abnormal behavior, and increased susceptibility to viral disease.[35]

The various PCB mixtures are highly toxic to several aquatic invertebrates and fish at extremely low concentrations. Aroclors 1248 and 1254 impair reproductivity of water fleas at concentrations as low as 0.48-1.0 ppb. Aroclor 1254 is toxic to several types of shrimp at levels of approximately 1 ppb. Substantially increased mortality of the fry of sheepshead minnows resulted from exposure to water containing 0.16 ppb of Aroclor 1254. It is thought that PCB levels of only a few parts per trillion in lake Michigan may be responsible for the reproductive failure of several species of fish in that body of water. There is also strong evidence that PCBs at concentrations below 1 ppb may adversely affect aquatic insects and crustaceans.[36]

Concentrations of Aroclors 1242, 1016, and 1254 as low as 0.1 ppb have been demonstrated to depress photosynthesis in phytoplankton and to reduce the rate of cell growth and division of these organisms. These effects are very significant since the productivity of the entire marine ecosystem may depend on the productivity of the phytoplankton within it.[37]

D. Toxicity of PCDFs

Polychlorinated dibenzofurans (PCDFs) are found in small but variable quantities as impurities in most PCB mixtures. In addition, PCDFs can be formed by photodegradation of PCBs in the environment. At present, it appears impossible to differentiate the toxic effects of PCBs from those of PCDFs. Consequently, it is necessary to regulate the commercial PCB mixtures with recognition that part of their toxicity may be attributable to unavoidable contaminants.[38]

E. Toxicity of PCB Metabolic Products

A number of studies have shown that PCBs are biodegraded into even more toxic metabolites. For example, it has been demonstrated that tetrachlorobiphenyl, which is a substantial component of several major commercial PCB mixtures, is transformed into toxic intermediate byproducts, including arene oxides and dihydrodiols. These substances have been found to cause cancer, mutations, and other toxic effects.[39]

F. Relative Toxicity of the PCB Mixture

PCBs are usually sold commercially as mixtures of biphenyl molecules with varying degrees of chlorination. Aroclors 1016 and 1242 have relatively low chlorine content, whereas the chlorine content of Aroclor 1254 is relatively high. It has been argued (174) that the less highly chlorinated mixtures and components may be less toxic and hazardous than the more highly chlorinated mixtures, and therefore the regulation of the former should be less stringent. This argument was considered in great detail at public hearings before EPA on Toxic Pollutant Effluent Standards for PCBs and was rejected by the Administrator.[40] There were several bases for not establishing separate standards for the different PCB mixtures. It was determined that all PCB mixtures then in use, including the less chlorinated ones (e.g., Aroclor 1016), are capable of inducing severe toxic effects at low levels in mammals and aquatic organisms. In addition, the compositions of the different PCB mixtures change and may become more similar after release into the environment, so that it would make no sense to regulate the mixtures, under different standards. Furthermore, important components of all the mixtures, including the less chlorinated ones, are highly persistent. Finally, while the less chlorinated components of the PCB mixtures are not stored in tissues as efficiently as the more highly chlorinated molecules, even the less chlorinated commercial mixtures have substantial amounts of components that are subject to significant uptake and storage.[41]

G. Inability to Establish a "Safe" Level of Exposure for PCBs

The available data indicate the PCB may cause several adverse effects in humans, mammals, birds, and aquatic organisms at extremely low concentations. Therefore, for all practical purposes, exposure of humans and other animals to any level of PCBs should be deemed significant. This is especially true in light of the demonstrated carcinogenicity of PCBs. EPA has adopted the view that "safe" or "threshold" levels for carcinogens cannot be established given the present state of scientific knowledge.[42] This policy has been upheld by the Federal courts in several decisions.[43]

Environmental Exposure to PCBs

A. General

The purpose of this section is to discuss how PCBs released anywhere into the environment may eventually become widely distributed, with the result that many organisms, including man, may become exposed. This section also summarizes some of the data indicating that PCBs are already widely distributed throughout the physical environment and the biosphere and that this environmental burden is not likely to become reduced in the near future because of the persistence of these chemicals.

B. Overview of PCB Transport in the Environment

Before presenting a detailed analysis of the manner in which humans and the general biota might be exposed to "free" PCBs (i.e., PCBs which have been released into the environment), it is first necessary to determine the processes by which free PCBs are distributed throughout the three compartments of the environment--air, land, and water. A number of processes affect the nature of this distribution. Once a PCB substance has entered a physical compartment, it may be dispersed throughout that compartment. In addition, each compartment may have sinks wherein free PCBs may be rendered physically unavailable to the biota or may be degraded by chemical or metabolic processes. Finally, a more or less continuous interchange of PCBs between the three compartments might be expected. The general nature of these processes is illustrated schematically in Figure 1,[44] and a summary of the possible sources, sinks, and exchange processes is given in Table 1.

It should be pointed out that the processes described in Figure 1 and enumerated in Table 1 are theoretical possibilities that apply to any environmental pollutant. Which of these processes play an important role in the environmental transport of PCBs is determined by the specific chemical and physical properties of the PCBs as well as the characteristics of each of the compartments. In

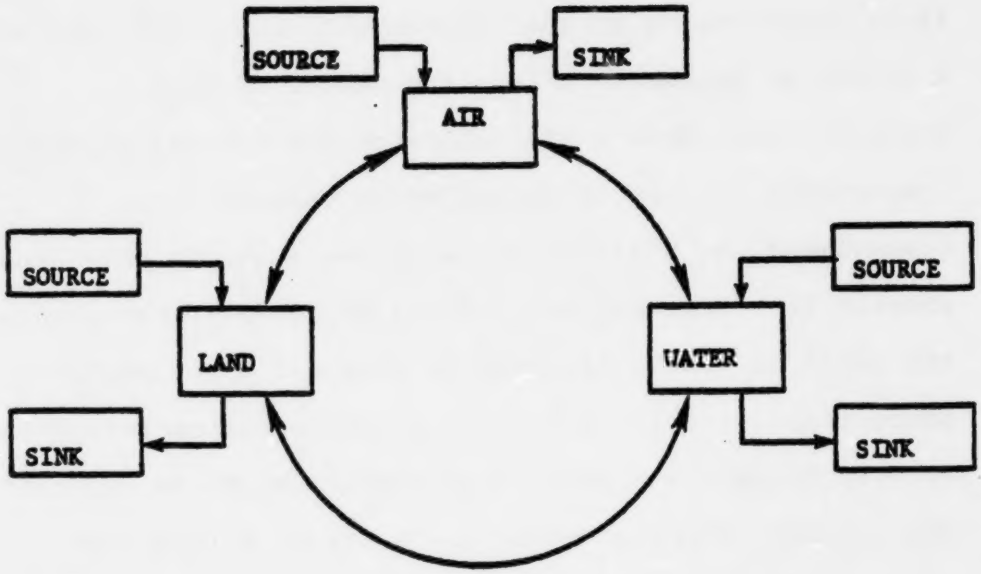
SOURCE
SINK
AIR
SOURCE
LAND
SINK
SOURCE
WATER
SINK

Figure 1

Schematic Representation of Transport Processes in the Environment

Table 1. Summary of Processes Involved in the Distribution of a Toxicant in the Environment

COMPARTMENT	SOURCES	EXCHANGE PROCESSES	SINKS
Atmosphere	Natural sources Gaseous residues from incineration of contaminated materials Evaporation during manufacturing processes Evaporation from consumer product uses Evaporation from accidental spills Degradation of other contaminants	Evaporation from terrestrial sources of free materials Coevaporation from contaminated water bodies	Photochemical reactions Oxidative reactions Reactions with other contaminants
Terrestrial	Degradation of discarded consumer products Industrial waste disposal by landfill Accidental spills Natural sources Degradation of other contaminants	Precipitation from contaminated air	Biodegradation - flora - fauna - microflora
Aqueous	Contaminated discharges Accidental spills Natural sources Degradation of other contaminants	Precipitation from contaminated air Runoff from contaminated soils Leachant processes from contaminated soils	Biodegradation - flora - fauna - microflora Chemical degradation - hydrolysis - photochemical - active chemical species reactions Sorption and entrapment onto fixed sediments

view of this, the physical and chemical properties of PCBs are discussed next, in order to lay the proper framework for a more detailed discussion of the transport of PCBs.

C. Environmentally Relevant Properties of PCBs

PCBs are a group of compounds, some 209 in number, that are prepared by the partial chlorination of biphenyl to yield a complex mixture of chlorobiphenyls in the form of high boiling point liquids of moderate viscosity. The environmentally significant physical properties of several of the commercial mixtures (Aroclors) are presented in Table 2. The properties of PCBs that have made them so commercially attractive include low water solubility, low affinity for water (high lipid solubility), a high degree of chemical stability, and very low vapor pressure at ambient temperatures. A more detailed discussion of the relevance of these properties to the environmental hazard posed by PCBs is presented in the following sections.

1. Chemistry of Chlorobiphenyls

Chlorobiphenyls have been demonstrated to undergo a number of chemical reactions. Both oxidation and hydrolysis of these chemicals can be carried out, but only under conditions that are considerably more rigorous than would be found in an environmental situation.[45] Another class of reactions to which PCBs are susceptible is that of cyclization. Of particular interest is the cyclization of

Table 2. Environmentally Relevant Properties of PCB Formulations

PARAMETER	AROCLOR 1242	AROCLOR 1248	AROCLOR 1254	AROCLOR 1260
Chlorine content (percent)	42	48	54	48
Water content, max. (ppm)	50	50	50	50
Distillation range (°C)	325-366	340-375	365-390	385-420
Evaporation loss (percent at 100°C, 6 hr)	3.0-3.6	3.0-4.0	1.1-1.3	0.5-0.8
Viscosity (sec at 37.8°C)	82-92	185-240	1800-2500	1200-4500 (54.5°C)
Water solubility (mg/l at 25°C)	0.24	5.4×10^{-2}	1.2×10^{-2}	2.7×10^{-3}
Vapor pressure (mm Hg at 25°C)	4.06×10^{-4}	4.94×10^{-4}	7.71×10^{-5}	4.05×10^{-5}
Volatilization half-life[47a] (from 1-m water column)	5.96 hr	58.3 min	1.2 min	28.8 min
Solubility in CH_3OH at 25°C	42.5 g/100 ml	--	15 g/100 ml	--
Octanol/water partition coefficient (est.)	3.5×10^3	6.4×10^3	1.18×10^4	2.2×10^4

2,2'dichlorobiphenyl, which yields the compound dichlorodibenzofuran.[46] The oral LD_{50} of the dibenzofuran for rats is approximately 250 mg/kg, whereas the LD_{50} for the chlorobiphenyl is in excess of 4000 mg/kg.[47]

As discussed below, it is thought that transport as a molecular species or as sorbed material on airborne particles is the major route of widespread transport of PCBs.[48] Since such processes would cause PCBs to be exposed to ultraviolet radiation from the sun, considerable attention has been directed to the photochemical stability of PCBs. A number of effects have been reported, including partial dechlorination and even, in some cases, the formation of very viscous semisolids apparently arising from some complex polymerization processes.[49] The environmental significance of these observations is difficult to assess since the solvents usually used in these studies were hydrocarbons rather than water.

The hydroxylation of the PCB molecule is the first step by which organisms metabolize this chemical.[50] Once the target chlorobiphenyl has been hydroxylated, there appears to be a wide variety of species-specific addition processes that can make use of the hydroxylated molecule. In this context, the failure to detect chlorodibenzofurans suggests that metabolic processes are not available to cyclize the PCBs. The further observation that the residual body burden of PCBs usually consists of only the more highly chlorinated PCBs suggests that the higher the level of chlorination, the more resistant it is to metabolic processes.[51]

Several of the PCBs with relatively low chlorine content are readily metabolized by direct hydroxylation by both animals and microorganisms.[52] Consequently, di- and trichlorobiphenyls are not very persistent.[53] On the other hand, the highly chlorine-substituted PCB molecules are apparently not metabolized at all. In addition, these species of PCB are not easily excreted because of their very low aqueous solubility and high lipid solubility. As a result, these species tend to accumulate in exposed animals.[54]

2. Physical Properties of PCBs

As indicated in Table 2, PCBs and their technical mixtures are characterized by low water solubility, low vapor pressure at ambient temperatures, and very high octanol/water partition coefficients.[55] The significance of the combination of low water solubility and high octanol/water partition coefficient is that when organic matter is exposed to an aqueous solution of PCBs, there is a strong tendency for the PCBs in the aqueous solution to be preferentially taken up by the organic matter.[56] Consequently, when animals are exposed to aqueous solutions of PCBs, the lipids of these animals will preferentially take up and store the PCBs. Since there is usually little metabolic activity in lipid bodies, the stored PCBs are, in some measure, protected from metabolic degradation. Therefore, larger and larger body burdens may be built up after continued exposure. It is this mechanism that accounts for the very large bioaccumulation factors that have been reported.[57]

In general, the volatility of a solute from a solution is governed by the vapor pressure of the (pure) solute at a given temperature and the mole fraction of the solute in the solution.[58] However, in those cases where there is either heat of mixing or change in volume when mixing the solvent and the solute (nonideal solutions), the volatility of the solute is not simply proportional to the molar concentration of the solute in the solution.[59] In those cases, it turns out that the lower the ultimate solubility, the greater the effective molar concentration. Thus, the volatility of the solute is significantly higher than would be expected for the given vapor pressure and the actual molar concentration. This phenomenon, which is known as codistillation, is responsible for the very short volatilization half-life of PCBs in water as illustrated by Table 2.[60] Codistillation from water is thought to be a major route of entry of PCBs into the atmospheric reservoir[61] and is believed to be responsible for the worldwide distribution of these substances.

D. Transport of PCBs in the Environment

This section discusses the mechanisms by which PCBs are transported from each compartment of the environment to the others.

1. Atmospheric Compartment

A number of investigators have determined that PCBs are very widespread in the atmosphere[62] both as molecular species and as adsorbed species on particulates and aerosols.[63] The mean air concentration of PCBs at several locations in Sweden was found to range from the detection limit of 0.8 to 3.9 ng/m^3. The highest detected level was 12.5 ng/m^3. In the United States, levels were found to range from 1 to 50 ng/m^3.[64] Over the Atlantic Ocean the airborne concentration was determined to range from 5 ng/m^3 near the northeast coast to 0.05 ng/m^3 at a distance of 2000 miles from the coast.[65] Numerous sources of airborne PCBs have been identified, including the incomplete incineration of PCB-containing materials (e.g., sewage sludge),[66] volatilization of PCBs from paints and plasticizers,[67] codistillation from surface waters that are PCB-contaminated,[68] and direct volatilization from PCB end uses and spills.[69]

Various writers have pointed out that the atmospheric reservoir of PCBs is the principal route by which the worldwide distribution of PCBs has occurred.[70] Thus the atmospheric reservoir serves as a mechanism for the dissemination of PCBs to the other compartments of the environment.

2. Terrestrial Compartment

The most significant sources of free PCBs in the terrestrial compartment of the environment include discarded consumer end use products that contain PCBs,[71] atmospheric fallout,[72] and spills associated with the use or the transport of PCBs.[73]

For that portion of the free PCBs that is confined to terrestrial sites, the primary mechanisms for dispersal are volatilization and solubilization by ground or surface waters. Since the vapor pressures of the typical PCB preparations (Aroclors) lie in the range of 10^{-2} to 10^{-4} mm Hg[74] at ambient temperatures, the loss rate by direct volatilization should be very small even in the absence of significant soil binding. It is possible, however, that under certain conditions heat produced by oxidation of organic materials in a landfill could raise temperatures significantly and thereby substantially increase the volatization of PCBs located in the fill.

PCBs are soluble in water so that direct solubilization by percolating waters is a possible mechanism for the admission of these substances into the ground waters. As an example, the limiting solubility of Aroclor 1254 in water is about 54 ppb,[75] and the average rainfall on the continental United States is about 34.5 inches per year.[76] It therefore follows that, with the normal long percolation time, the losses into the local ground waters could be as high as 0.04 g/m^2/year in a region where PCBs have been landfilled.

In addition to solubilization, PCBs may be removed from land and enter the aquatic compartment by surface water runoff. This latter effect is of great concern in areas where contaminated oils have been used on highways or where land spills of PCBs are possible. There is no direct evidence that PCBs are degraded by soil microflora.[77]

3. Aquatic Compartment

Figure 2 illustrates the nature of the processes that are involved in the transport of PCBs to and from a body of water. It illustrates that the principal PCB inputs to a body of water are contaminated inflowing streams and the PCBs that precipitate from the atmospheric reservoir. An example of the significance of the inflowing streams is given in a recent report[78] which indicates that detectable PCB levels were found in some 40 percent of a total of 900

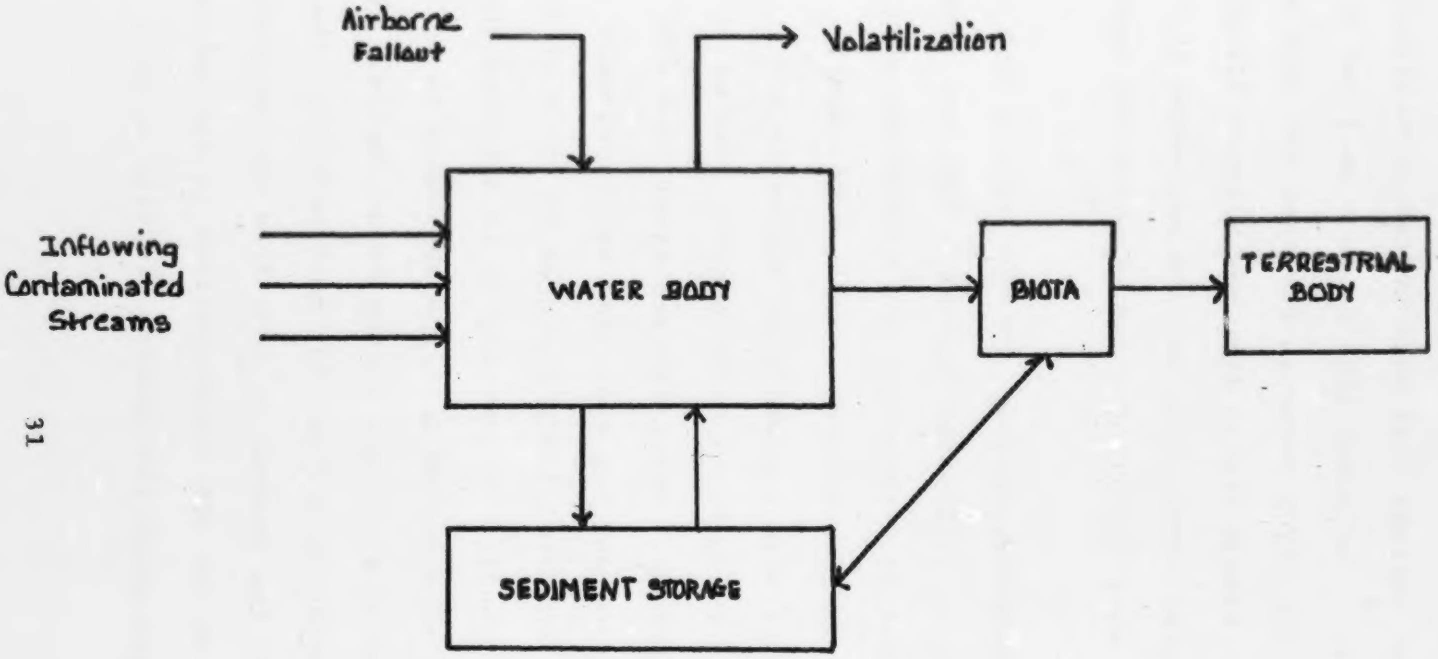
Airborne Fallout
Volatilization
Inflowing Contaminated Streams
WATER BODY
BIOTA
TERRESTRIAL BODY
SEDIMENT STORAGE

Figure 2

Model of Sources and Sinks for a Body of Water industrial effluent streams that were tested in Michigan. An earlier estimate[79] indicated that as much as 1 ton of PCBs was entering the Clyde River in Scotland per year as a component of crude sewage sludge from the Glasgow district. In addition, as noted above, PCBs on land may enter the aquatic reservoir as a result of solubilization and surface water runoff.

It has been demonstrated that the PCBs have a high affinity for soils in soil-water systems[80] but that these hydrosoils may serve as a reservoir for resolution when the PCB concentration in the sediments become sufficiently high.[81] In addition, when contaminated sediments are disturbed (as, for example, in river scour), some of the PCBs may be resuspended. The processes associated with desorption from a sorbent may also tend to fractionate the components of the commercial PCB mixtures in favor of the more soluble components. In general, it is believed that the material that is adsorbed onto the sediments is eventually removed by migration to the ocean depths. Thus, the sediments constitute a sink and, most probably, the principal sink for the removal of PCBs from the environment.

Measurements of the PCB concentrations in the sediments in the Hudson River above the General Electric outfall indicated levels ranging from 0.0 to 16.8 ppm. At Thomson Island, about 1 mile downstream, typical sediment levels ranged up to 3700 ppm,[83] with the PCB levels in the overwaters ranging from 0.06 to 3.0 ppm. Fish collected within 1 mile of the General Electric outfall contained PCB levels ranging from 78 ppm in minnows to 350 ppm in rock bass.[84] Striped bass sampled near West Point (well over 100 miles downstream of the GE outfall) had PCB residuls of between 1.16 and 7.54 ppm.[85] The magnitude of the PCB losses through the process of volatilization (codistillation) is not fully established, but there is general agreement, as noted above, that this process is of significance in the detailed mass balance for an aqueous system. Volatilization from the air/water interface is a principal source of the atmospheric reservoir of PCBs.[86]

E. Exposure to PCBs

1. Current Environmental Load of PCBs

It has been estimated that between 300 and 400 million pounds of PCBs entered the general environment up to and including 1975. Of this total, it is estimated that some 25 to 30 percent is free material and thus constitutes the reservoir from which exposure of the biota might occur.[87] The remainder of the environmental load, mostly in the form of industrial waste and discarded end use products, is believed to be in landfill sites and thus constitutes a potential source of new free PCBs. It is further estimated that, at any given time, approximately one-third of the non-terrestrial free PCBs are in the atmospheric reservoir, while the remaining two-thirds are in the aquatic reservoir.[88]

2. Exposure of Organisms to the Terrestrial Reservoir of PCBs

As pointed out above, the largest portion of the terrestrial reservoir of PCBs remains in the discarded PCB-containing products that are contained in landfills.[89] The average soil concentration of PCBs taken in non-landfill areas has been found to be below detection level.[90] A recent report[91] indicates that only 0.1 percent of the soil samples analyzed showed detectable PCB levels. Sixty-three percent of the contaminated sample were from urban areas.[92] It is not clear whether any substantial exposure of the biota to the terrestrial reservoir of PCBs occurs.

3. Exposure of Organisms to the Atmospheric Reservoir of PCBs

Inhalation and dermal contact by humans and other animals are two possible modes of exposure to the atmospheric reservoir of PCBs. Although measurements taken at widely separated points have shown that there is a detectable level of PCBs in most air samples, the observed levels are close to the limits of detection except in the vicinity of PCB sources.[93] If the estimated atmospheric load noted above were uniformly distributed throughout the atmosphere, the concentration of PCBs in the air would be approximately 5 ng/m^3.

4. Exposure of Organisms to the Aquatic Reservoir of PCBs

The rather complex relationship between the aqueous phase, the biota, and the sediments is illustrated in Figure 2 by the interconnecting lines in the figure. The biota-incorporate PCBs either by direct sorption from the contaminated waters or through the food chain relationship between the benthic organisms living within the contaminated sediments and the free-swimming organisms. There can be little doubt that the direct pickup of PCBs from the surrounding waters is a major route by which these compounds enter the biota. A large number of marine and freshwater species have been demonstrated to take up PCBs selectively from surrounding water and concentrate these compounds at levels many times higher than those in the water. The phenomenon is known as bioconcentration. A typical example[94] is the reported bioconcentration of PCBs by the fathead minnow by a factor of 230,000.

Currently, there is considerable disagreement as to the role played by the process of bioaccumulation in the contamination of aquatic organisms. However, this process is apparently the major source of PCB contamination of terrestrial animals that feed upon aquatic organisms. This relationship is illustrated by the right-hand side of Figure 2. It should be noted that terrestrial animals may have significantly higher concentrations of PCBs in their tissues than the aquatic forms they feed on. For example, while cod and pike have been found with PCB levels on the order of 10 mg/kg of extractable fat, fish-eating birds such as herring gulls and cormorants have been found with levels of 600-700 mg/kg and 400 mg/kg of extractable fat, respectively.

However, the impact of this route of exposure is not limited to aquatic species. Man as well as fish-eating terrestrial animals and birds also may be adversely affected. Fish constitute a substantial part of man's diet. Therefore, the concentration of PCBs in fish gives man the choice of either giving up an important food source or subjecting himself to the adverse effects of PCBs. In addition, man may be exposed to lower levels of PCBs by drinking contaminated water.

F. Present Distribution of PCBs in the Environment

This document has shown that the additional release of PCBs into any of the environmental compartments may be expected to result in widespread distribution into all these compartments and will eventually expose large populations of wildlife and man to PCBs. This conclusion is further supported by the fact that PCBs are already widespread in the physical environment and in the biosphere.

Since the earliest identification of PCBs in fish samples,[95] literally thousands of environmental and ecological samples from all over the world have been analyzed and reported to contain PCB. For example, PCBs have been identified in Antarctic ice samples from depths as great as 5.5-6 meters.[96] Sea and air samples taken in the Sargasso Sea showed PCB levels on the order of 1 ng/m^3 in the air samples and up to 10 ng/l in the sea samples. Approximately 75% of human adipose tissue samples taken from 31 persons in the United States in 1973, showed PCB levels ranging from 1 to greater than 3 ppm.[98] Polar bears, sampled as indicators of the top trophic level in arctic and subarctic food chains, have been shown to have PCB levels of up to 8 ppm (wet weight in fat).[99] Seals taken from a variety of Canadian waters show levels of from a few ppm to a high of 52 ppm.[100] In addition, PCBs have been detected, frequently at high levels, in a large number of fish and bird species inhabiting widely separated geographic areas.[101] These samples, which are by no means all-inclusive, indicate that PCBs are a global problem.

G. Conclusions

PCBs have been demonstrated to cause a number of severe adverse effects on many living organisms at very low concentrations. As a practical matter, it is not possible to determine a "safe" level of exposure to these chemicals. Because PCBs are already widely distributed throughout the biosphere, they currently pose a significant risk to the health of man as well as that of numerous other living things. As a consequence, any further increase in levels of PCBs in the biosphere is deemed undesirable by EPA. It has also been demonstrated that PCBs released anywhere into the environment will eventually enter the biosphere. Therefore, as a corollary, EPA has determined that any such release of PCBs must be considered "significant."

III. PCB SUBSTITUTES*

The following is a discussion of substitutes available or in the process of development for PCB dielectric fluid used in capacitors and transformers. This discussion of substitutes is intended as a brief summary. Inclusion or omission of any substance in this discussion should not be construed as an indication of EPA approval or disapproval of its use.

A. Capacitors

1. Phthalate Ester[1]

Dioctyl Phthalate (DOP) has been used in capacitors manufactured in Japan since 1974. It is presently being used in most of the capacitors manufactured in the United States.

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*The information on substitutes for PCB Capacitors and Transformers was primarily based on data contained in the Versar study, PCBs in the United States: Industrial Use and Environmental Distribution. Some of the facts in that study were updated based on a review by Versar of this discussion of substitutes prior to issuance of the Draft Support Document. Information on Uniroyal PAO-20E was provided by the Uniroyal Chemical Company prior to preparation of the Draft Support Document.

Advantages of DOP are: (1) the cost is approximately one-half that of PCBs; (2) DOP is available as a substitute since it is currently used as a plasticizer for polyvinyl chloride; and (3) its dielectric constant is 5.3, similar to that of PCB.

Disadvantages of DOP are: (1) the maximum service temperature of capacitors containing DOP is 85°C, as opposed to 95°C for PCB; and (2) the corona inception voltage is lower than that of PCB but can be raised by the addition of trichlorobenzene to the mixture.

Diisononyl phthalate is a potential substitute for PCB. It is manufactured by Exxon under the tradename Enjoy 2065 and is not available in large quantities. Diisononyl phthalate is similar to DOP, although it is more stable chemically.

The flash points for DOP and diisononyl phthalate are relatively high (220° for DOP), yet both of these phthalate esters are more flammable than PCBs. It should be noted that a particular class of phthalate esters, the alkyl phthalates, were recommended for testing by the TSCA Interagency Testing Committee[2].

2. Alkylated Chlorodiphenyl Oxide[3]

Butylated monochlorodiphenyl oxide is marketed by Dow Chemical Company under the tradename XFS-4169L.

Based on four years of testing, McGraw-Edison, a capacitor manufacturer, has found this material (which they tradenamed EDISOL) to be a "viable substitute" for PCBs in high voltage power capacitors. Although the dielectric constant of EDISOL is somewhat lower than that of PCB (4.5 versus 5.85), the size of EDISOL capacitors marketed by McGraw-Edison is the same as PCB capacitors at equal KVAR ratings.

Advantages of butylated monochlorodiphenyl oxides are: (1) a lower loss-tangent; (2) a higher corona inception voltage than PCB by 20 to 30 percent; (3) a higher flash point (174°C). Advantages of this substitute vis-a-vis toxicity are that it (1) is more biodegradable than trichlorobiphenyl; (2) has been shown to be nonmutagenic in an Ames test; (3) has a lower bioconcentration factor than PCB; (4) has a lower adipose concentration than PCB; and (5) does not show chloracnegenicity.

Disadvantages of butylated monochlorodiphenyl oxide are: (1) the higher material costs; and (2) a lower fire point (199°C) than that of PCB.

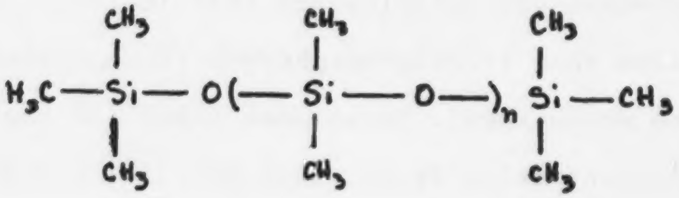
B. Transformers

1. Fluorocarbons[4]

Certain fluorocarbon compounds have properties similar to PCBs. Fluorocarbons are highly volatile in comparison to PCB, and they are about six times as expensive. Perfluoroethane is extensively used as a dielectric gas in totally enclosed gas filled transformers, which can be used to replace PCB Transformers in certain hazardous locations.

2. Silicones[5]

Low viscosity silicone fluids, on the order of 50 centistokes, are possible substitutes for PCBs in transformers. They are produced by General Electric, Dow Corning, Union Carbide, and SWS Silicones. Polydimethyl siloxane, a potential substitute, has the molecular structure:



$$H_3C-\overset{CH_3}{\underset{CH_3}{\mathrm{Si}}}-O(-\overset{CH_3}{\underset{CH_3}{\mathrm{Si}}}-O-)_n\overset{CH_3}{\underset{CH_3}{\mathrm{Si}}}-CH_3$$

Silicone fluids have the special advantage of a relatively temperature-independent viscosity. The silicone fluids have somewhat poorer heat transfer characteristics than askarel but can be substituted directly for askarel in existing transformers, resulting in only a small decrease in the transformer rating.

Electrical Properties:

Dielectric Constant	2.72
Dielectric Strength	200 volt/mil
Resistivity	7.1×10^{14} ohm-cm
Dissipation Factor	1.8×10^{-5} at 100 Hz, 23°C

Polydimethyl siloxane has a higher flash point than conventional, non-PCB transformer coolants: 280°C for mineral oil (PCBs have no true flash point.) The heat of combustion of 50 centistoke polydimethyl siloxane is lower than that of mineral oil--7.67 kcal/gm versus 11.0 kcal/gm--and since the silicones burn more slowly, they are considered poor fuel.

On the Underwriters Laboratories' fire hazard classification (in which water is rated as 0 and ether as 100) polydimethyl siloxane is classified as 4 to 5, which is slightly higher than the 2 to 3 rating given to PCBs, but is considerably less than the mineral oil rating of 10 to 20.

These compounds do not biodegrade, as measured by sewage sludge breakdown to CO_2. However, there is evidence that they partly depolymerize to low molecular weight compounds upon contact with soil and water. Since ultraviolet light decomposes methyl silicones, sunlight exposure may be the mechanism for environmental degradation.

No tendency for bioaccumulation or bioconcentration has occurred in experiments. In mammals, the compound is not absorbed through the gastrointestinal tract or the skin.

The PCB substitute developed by Dow Corning for transformers is called DC561. This is a mixture of polydimethyl siloxanes of various chain lengths which have a viscosity of 50CS. The literature on environmental and health characteristics of silicones makes reference to at least six fluids, most of which are probably similar to the DC561, but some of which could be other mixtures with certain additives. By necessity, the usefulness of published toxicological data depends on the validity of the assumption that all of these compounds have identical persistence, bioaccumulation, and toxicity properties.

A review of toxicological studies of silicones reported the following results:

Dietary Toxicity:

LD_{50} (rats) >28 gm/kg

Extended Feeding Tests:

Guinea pigs--47 gm/kg/day for extended period--no toxic effect.

Mallard ducklings and bobwhite quail--5000 ppm for 5 days--no effect.

Rats--20 gm/kg/day for 28 days--no effect.

Rats--190 mg/kg/day for 90 days--no effect.

Beagle dogs--300 mg/kg/day for 120 days--no effect.

Mice--3 percent in diet for 80 weeks--no effect.

Man--FDA allows silicones as food additives at up to 10 ppm.

The major deficiency in knowledge of the silicones appears to be in their fate in the environment and the toxicity of their breakdown products.

The silicone transformer fluids currently cost up to twice as much as PCBs on a volume basis.

Dow Corning has completed evaluation of polydimethyl siloxane as a high voltage insulating fluid. They report, though, that a near term 100 percent replacement of PCBs in transformers by this fluid is not possible. If a transformer market were to develop for polydimethyl siloxane, the present domestic capacity could be adequate to supply new transformers. The time lag for a 100 percent replacement of PCBs in transformers by polydimethyl siloxane would be on the order of 5 to 10 years.

3. Mineral Oils[6]

Mineral oils are widely used in transformers. The flash point of mineral oils is a function of its molecular weight. Since crude petroleum can be refined to have any required molecular weight over a wide range, it is possible to specify any particular flash point that is desired for the minimal oil transformer liquid. This approach has been taken by RTE Corporation in the development of their proprietary transformer liquid, which has the tradename RTEmp.

RTEmp is a highly refined paraffinic mineral oil that has a flash point of 285°C, approximately the same as the 50CS silicone liquid proposed by Dow Corning as a PCB substitute. To achieve this higher flash point, the oil is refined to have a higher molecular weight and consequently a higher viscosity, which reduces its effectiveness in convective cooling.

The major current advantage of the high flash point mineral oils is their low price relative to silicone and askarel and their inherent biodegradability and low toxicity.

4. Synthetic Hydrocarbons[7]

Certain mixtures of synthetic hydrocarbons may result in a liquid having the high flash point characteristics of RTEmp or silicone combined with the relatively low viscosity and satisfactory heat transfer characteristics. Examples of synthetic hydrocarbons being tested as PCB substitutes include FR Dielectric Fluid manufactured by Gulf Oil Chemical Company and PAO-20E produced by Uniroyal Chemical.

PAO-20E[8] was designed for use in transformers. Its dielectric strength (KV/0.25 cm) is 50, and its dielectric constant is 2.15, as compared with 40 and 4.3, respectively, for PCB. It has a flash point of 276°C and a fire point of 307°C. Its acute oral LD_{50} (rats) is over 40 mg/kg.

IV. SIGNIFICANT EXPOSURE/TOTALLY ENCLOSED MANNER

A number of persons commented on the Agency's proposed definition of the term "significant exposure". This term was defined as any exposure of human beings or the environment to PCB chemical substances or PCB mixtures as measured or detected by any scientifically acceptable analytical method. The majority of the persons who commented objected to the proposed definition (6, 31, 35, 38, 42, 46, 70, 81, 86, 94, 97, 116, 139, 140, 151, 167, 174, 208, 215, 216). Some persons stated that there was a lack of adequate health and environmental effects data to justify such a stringent position (31, 46, 140, 138, 215, 216). Some of these persons stated that the Agency's zero exposure limit was unfounded particularly in light of the Center for Disease Control (CDC) epidemiological study* on the exposure of PCBs in Bloomington, Indiana. They also contended that a National Cancer Institute (NCI) bioassay** of Aroclor 1254 for possible carcinogenicity refuted earlier data on the carcinogenicity of PCBs (82, 46).

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*USDHEW, Center for Disease Control. Exposure to Polychlorinated Biphenyls in Bloomington, Indiana. Atlanta: Public Health Service, EPI-77-35-2, (May 26, 1978).

**USDHEW, PHS, NIH, NCI. Bioassay of Aroclor 1254 for Possible Carcinogenicity. Washington: National Cancer Institutes, Tech. Report Series No. 38, (1978).

Two persons, however, agreed with the Agency's decision to define "significant exposure" as any exposure (85, 182). One person pointed out that the NCI and CDC studies do not invalidate any of the results of previous studies indicating that PCBs pose a carcinogenic risk to man. This person also pointed out that scientists have observed other adverse health effects from exposure to PCBs.

After reviewing all these comments and the CDC and NCI studies, the Agency concludes that no change in its evaluation of the health hazards of PCBs is warranted or appropriate. The CDC study was not designed to determine the carcinogenicity of PCBs; therefore, that study is not relevant for purposes of evaluating the carcinogenic risk posed by PCBs. Furthermore, the study established that humans exposed to PCBs had elevated serum levels of gamma glutamyl transpeptidase (a liver enzyme) and triglycerides. These effects indicate that PCBs cause enzyme induction and may damage the liver in humans. The elevation of serum triglyceride levels has additional significance in that such elevations have been associated with atherosclerotic cardiovascular disease. In sum, it is apparent that the CDC study, rather than undermining the Agency's conclusions about the hazards of PCBs, supports these conclusions.

The NCI study cannot be considered to establish non-carcinogenicity. The study showed certain trends which raise concern about the carcinogenicity of Aroclor 1254.

For example, liver and gastrointestinal tumors were found in rats treated with Aroclor 1254 but not in controls. The incidence of these tumors was not statistically significant. However, lack of statistical significance may be a result of insufficient numbers of animals used in the experiment.

In conclusion, the comments submitted and the CDC and NCI studies do not warrant any change in the Agency's evaluation of the adverse health and environmental effects caused by PCBs. In particular, no acceptable reason has been provided for rejecting the results of several studies which indicate that Aroclor 1254 and other PCB mixtures are carcinogens and cause numerous other adverse effects. Therefore, the Agency adheres to its conclusion that the release of any quantity of PCBs into the environment is significant.

Further objections to the definition of "significant exposure" were that the proposed definition makes compliance difficult and could deter clean-up of existing contamination (31, 46, 70, 16, 139, 140, 151, 167, 208, 216). Persons stated that any housekeeping or maintenance operation will necessitate some human or environmental exposure to PCBs. To alleviate this problem some persons suggested that the Agency take into consideration, when defining "significant exposure", such factors as (1) industry's existing safe handling practices, (2) Occupational Safety and Health Administration (OSHA) regulations which control a substantial portion of the potential worker exposure from maintenance and housekeeping operations, and (3) the distinction between existing and newly introduced PCBs.

These comments indicate a misunderstanding of the Agency's criteria for defining "totally enclosed manner." The Administrator is required by §6(e)(2)(B) to define by rule the term "totally enclosed manner" as the manner which will ensure that any exposure of human beings or the environment to a PCB will be insignificant. This language clearly indicates that the Agency's definition of "totally enclosed manner" is to be based strictly upon health and environmental factors. Nowhere does TSCA state that in defining "totally enclosed manner", the Agency is to consider technological feasibility, economic impact, or current industry practices. It is the Agency's understanding that this same rationale can be applied to defining "significant exposure". As General Electric (58) commented, the term "significant exposure" is different from the definition of "unreasonable risk" and is used solely for the purposes of defining "totally enclosed manner".

Thus although such factors as technological feasibility, economic impact, or current industry practices are not considered in determining "significant exposure", they are considered, among other factors, by the Agency in deciding whether or not an activity presents an "unreasonable risk" to health and the environment. If an activity is found not to present an "unreasonable risk", an authorization and an exemption for such an activity to take place in a non-totally enclosed manner may be granted.

V. PCB DEFINITION: 50 PPM

A large number of persons representing industry and environmental action groups commented on the Agency's decision to lower the definition of "PCB Mixture" from 500 ppm to 50 ppm PCB. Some persons were concerned that 50 ppm was too high (53, 84, 92, 126, 211, VIII TR, p. 172-178) because there existed a health and environmental risk from PCBs even at levels below 50 ppm. The majority of these persons suggested that EPA lower the level at which PCBs would be regulated.

Three persons agreed with the Agency's decision and reasons, as stated in the proposed rule, for lowering the level defining a "PCB Mixture" to 50 ppm (57, 85, 101). One person stated that lowering the definition to 50 ppm would not have a detrimental effect on his industry (158).

The majority of persons commenting on this action disagreed with the Agency's proposal to lower the definition of "PCB Mixture" to 50 ppm. Their first objection was based upon what they perceived to be either the lack of sufficient economic information to determine the impact or the substantially greater economic impact that would be incurred by industry and the national economy by lowering the definition from 500 to 50 ppm. This impact, they thought, was unreasonable and, therefore, contrary to Congress' intent (3, 4, 6, 11, 15, 17, 20, 25, 31, 35, 36, 37, 46, 49, 55, 58, 62, 69, 70, 71, 72, 75, 80, 87, 89, 90, 91, 93, 94, 95, 96, 97, 99, 100, 104, 106, 109, 116, 122, 123, 133, 134, 137, 138, 139, 140, 145, 146, 147, 150, 151, 152, 156, 161, 165, 167, 170, 174, 178, 189, 190, 191, 201, 202, 208, 216, IV TR, p. 7, V TR, p. 41).

These persons attributed the impact to a variety of reasons. First, they thought that lowering the concentration for regulating PCBs would require the affected industries to spend more money on the additional requirements for recordkeeping, testing, draining and flushing, specialized storage and containers. Second, they thought the affected businesses would incur a loss as a result of the premature disposal of PCB Articles and PCB-contaminated fluids. Third, they thought the restrictions on allowable repair may cause some industries to reduce their maintenance force. Lastly, they felt that industry would incur a loss from shut down of certain PCB Articles while these articles were being replaced or were being serviced in order to bring the article into compliance with the rule. These impacts, they believed, would affect all sectors of the economy including industries, consumers, and workers.

A substantial number of comments were received indicating that the Agency was lacking prudence in lowering the definition of "PCB Mixture" to 50 ppm. They felt that by banning the current industry practice of burning of PCB contaminated fuels and by indirectly causing an increased demand for fuel needed to transport PCBs to approved incinerators, the Agency was aggravating energy problems in the U.S. (11, 29, 36, 47, 49, 55, 134, 150, 198).

The Agency has reviewed all the comments and the accompanying economic data that was submitted in regard to this 50 ppm vs. 500 ppm issue. None of these comments provide evidence that changes the Agency's finding that 50 ppm is the most reasonable concentration at which to regulate PCBs. (For a thorough discussion of the Agency's rationale for regulating PCB above 50 ppm see section II.B in the Preamble to the final rule.)

The Agency, however, has modified the rule to reduce the economic consequences to industry of the restrictions on PCBs and PCB Articles containing greater than 50 ppm PCB to the extent possible without compromising necessary protection to health and the environment. (For a discussion of the Agency's justification for reaching these conclusions, see section III, Changes in Subpart B: Disposal of PCBs and PCB Items, as found in the Preamble to the rule). First, the Agency is allowing persons to dispose of PCB-contaminated fluids between 50 and 500 ppm PCB, in high efficiency boilers. Second, for those industries who do not have access to high efficiency boilers or who prefer landfill disposal, the Agency is permitting the use of chemical waste landfills for the disposal of such PCB-contaminated fluids, subject to certain conditions. Third, the Agency is permitting the recycling of mineral oil. Lastly, the Agency has decided to allow persons to drain mineral oil transformer fluids contaminated with PCBs in the range of 50 to 500 ppm into collection tanks and test the batched mineral oil instead of requiring them to test each individual transformer. These practices will substantially reduce the cost of disposal and testing.

The Agency believes that the changes that have been made in the rule, particularly the changes in testing and disposal requirements for PCB liquids, will permit the use of PCB-contaminated mineral oil dielectric fluid as a fuel and will therefore alleviate some of the cost to the consumer and the power industry for energy. In addition, by permitting other methods of disposal that may be more conveniently located, the Agency is also reducing the demand for fuel needed to transport PCBs and PCB Items to disposal facilities.

Some persons objected to the proposed definition because they did not believe that the Agency had sufficient health and environmental justification for regulating PCB at 50 ppm particularly in light of the economic impact. These persons, in general, felt that the economic impact far outweighed the adverse health and environmental effects

(11, 15, 31, 36, 69, 70, 71, 81, 89, 91, 93, 94, 95, 100, 109, 140, 145, 146, 147, 148, 150, 156, 165, 198, IV TR, p. 7). In some cases these persons felt that there was no data that suggested that there was any health and environmental hazard from PCBs (6, 29, 59, 96, 97, 116, 199, 122, 123, 132, 172, 191).

The Agency disagrees that there are insufficient adverse health effects data to warrant regulations below 500 ppm. PCBs at levels below 500 ppm have been shown to cause a variety of adverse health effects in animals including malignant and benign tumors, enzyme induction, immunological suppression, and fetotoxic, mutagenic, and reproductive effects. (A more detailed discussion of these health effects is discussed in Section II of this document.)

Some persons objected to the proposed 50 ppm definition for reasons of inadequate analytical chemistry capability. These persons contended that reliable analytical results were unobtainable because either the methods were invalid or because they were unable to find a laboratory that was able to supply reliable results (18, 29, 95, 97, 202). Other persons objected because there were not enough laboratories to perform these tests (31, 95) or because the already existing laboratories would become overburdened with work thus aggravating the delay in receipt of results (88).

They felt that unless there was a valid method for analyzing PCBs at low levels in oils and chemical products such as pigments, industry could not be expected to comply with the rule.

The Agency disagrees with these comments. A variety of accepted analytical methods for measuring the concentration of PCBs in several media are currently available. A number of these methods are described in the Preamble to the rule in Section III. In addition, commercial and industrial laboratories are capable of using these methods to produce valid analytical results for PCBs. Industries with specialized analytical expertise for their product, e.g., pigments, will be expected to adopt appropriate PCB analytical methods to determine PCB concentrations in their processes or products.

Some commentors thought that because 1) EPA was increasing the amount of PCBs that had to be handled by lowering the applicable PCB concentration from 500 to 50 ppm and 2) the distances to EPA approved incinerator or disposal facilities may be far, EPA was actually increasing the chances that this material might be accidentally released to the environment (36, 81, 90, 146, 152, 172, 198, IV TR, p. 7).

As a result of the Agency's decision to permit certain PCBs and PCB Items to be disposed of in chemical waste landfills and high efficiency boilers in addition to high temperature incinerators, the number of approved facilities will be expanded. This should reduce the likelihood of environmental contamination from spills as the distance over which these materials must be transported is reduced. In addition, the Agency is also requiring persons who possess PCBs to comply with certain spill prevention practices (see Preamble section V.C.3).

One person stated that the proposed 50 ppm definition would have a disproportionate impact on small businesses because in most cases small businesses are unable to perform their own testing. They must therefore rely on independent organizations and would need substantially more time to test for PCBs than would be needed by large businesses who could perform their own testing. The commentor suggested that the delay in receipt of the results for transformer testing could increase the time that the transformer is out of service (87).

The Agency is aware that small businesses have to rely on outside testing laboratories to a greater extent than large businesses. However, the final rules greatly reduce the need for testing by allowing persons to make certain assumptions about the transformer, based upon its history. This alternative benefits small and large businesses equally.

A variety of alternative regulatory techniques other than the ones adopted by the Agency were suggested. A number of persons recommended that EPA raise the lower level at which the Agency is regulating PCBs and PCB Articles to levels above 50 ppm and/or postpone the effective date by which persons must comply with this level. (500 ppm was the most frequently recommended level.) (31, 34, 36, 37, 49, 54, 59, 72, 75, 81, 87, 89, 91, 94, 95, 102, 104, 116, 119, 122, 123, 132, 133, 137, 139, 146, 150, 156, 161, 174, 188, 189, 190, 191, V TR p. 139) Others suggested that EPA apply the restrictions on the disposal of articles that contain greater than 50 ppm only if the total amount of PCBs in the articles exceeds a specified amount (15, 49, V TR, p. 21).

The Agency considered these suggested alternatives and believes that the approach that it has taken in the final rule is the best method for both controlling the risks from PCB and minimizing the economic impact.

The Agency believes that the first alternative is unacceptable because it would allow a substantial amount of PCB to escape to the environment since many activities involving PCB-contaminated materials would go unregulated. For the most frequently mentioned cut-off level, 500 ppm, the Agency has predicted that at least 1 million pounds of existing PCBs (using data developed by Versar) and 100,000 to 500,000 pounds per year of newly manufactured PCBs (using data from manufacturing petitions) could escape to the environment. The later numbers are based upon the assumption that the 60,000 or so pounds that industry suggested is an underestimate. The Agency believes that chere are some pigment manufacturers that have not submitted an exemption request because they have assumed, erroneously, that they do not need to do so.

The second alternative is a more complicated approach to implement because of the difficulty with using poundage instead of concentration limits as a trigger for requiring compliance with restricted disposal procedures. The problem becomes particularly pronounced when a volume of PCB liquid is in someway combined with other PCB liquids changing the pounds of PCB per container. The Agency believes that its use of concentrations to define applicability is much simpler, more easily implemented, and achieves the same goal of defining a reasonable level at which to regulate PCBs. As discussed above, alternative methods of disposal such as high efficiency boilers, chemical waste landfills, and the use of batch testing should substantially reduce the cost of this rule.

VI. DILUTION

One pigment manufacturer stated that some persons in the pigment industry would have difficulty complying with the anti-dilution clause in the proposed rule (VII TR, p. 9). He stated that some pigment manufacturers produce pigments in batches and then blend the batches to insure uniformity. Two persons stated that because, as they believed, the dilution constraint was aimed at persons who might consider diluting in order to avoid complying with EPA's disposal procedures, EPA should qualify the rule by stating that normal manufacturing operations such as blending do not constitute "dilution" (174 VII TR, p. 9,).

The Agency agrees that the blending and subsequent use of chemicals such as pigments was not the type of dilution that EPA wanted to control. Person's who, for operational reasons, dilute their PCBs in a manner not specifically authorized by EPA, may request an exemption from the prohibitions on dilution. These exemptions will be dealt with on a case-by-case basis. See section II.C of the Preamble for a discussion of the dilution provisions.

One person asked that reduction of PCB concentration that occurs during an authorized activity, such as refilling hydraulic systems, not be subject to the prohibitions on dilution (101).

One person also objected to the restrictions against unintentional dilution as contained in the definition of PCB mixture (29). He stated that EPA needs to distinguish more adequately between dilution to avoid disposal compliance and dilution from unintentional contamination. He also recommended that EPA exclude non-PCB contaminated fluids from the definition of PCB mixture when the PCB concentration is less than 50 ppm (29).

The Agency agrees with this comment and again has accordingly modified the final rule by deleting the defined term "PCB Mixture" and by explaining in the Preamble (see sections II.C.4.a and III.E of the Preamble) the circumstances under which intentional and unintentional dilution resulting in improper disposal of PCBs or PCB Articles, constitutes a violation of the rule. As part of these changes, the final rule no longer restricts the disposal of PCBs that contain less than 50 ppm PCB as long as the PCB concentration was the result of activities permitted by an authorization. The Agency, however, is restricting the disposal of PCB-contaminated fluid above 50 ppm whether or not the PCBs are present as a result of unintentional contamination. The Agency believes that whether or not PCBs are the result of intentional or unintentional action, PCBs above 50 ppm pose a health and environmental risk. (See section II.B of the Preamble for a more explicit discussion of the Agency's reasons for choosing 50 ppm as the cut-off concentration.)

VII. TRANSFORMERS

The Agency's proposal to regulate mineral oil transformers that are contaminated with PCBs resulted in a large number of comments, especially from electric utilities and transformer servicing and manufacturing companies. A few comments argued that the rule, as it related to PCB and mineral oil transformers, went beyond the intent of the TSCA (46, 49, 97, 156, 169, III TR, p. 124, IV TR, p. 5).

The Agency believes TSCA is clear in giving EPA authority to regulate the manufacturing, processing, distribution in commerce, and use of PCBs in transformers. Transformers, inasmuch as they contain PCBs or PCB contamination, are subject to control under the authority of TSCA. (See Section XII of this Support Document for a discussion of the justification for regulating PCB Articles and PCB Equipment.) The extent of controls on transformers has been determined by a process of considering both the clear benefits resulting from transformer activities and the potential environmental and human hazards that can result from those activities.

Many of those commenting expressed the belief that the environmental, economic, and energy trade-offs had not been fully and properly weighed (11, 35, 44, 46, 48, 49, 53, 55, 57, 60, 70, 71, 82, 83, 91, 96, 97, 100, 109, 110, 121, 129, 131, 134, 137, 140, 150, 156, 167, 170, 189, 190, 196, 208, 210, 216, 218, I TR, p. 22, I TR, p. 118, II TR, p. 6-7, II TR, p. 60, III TR, p. 138, VII TR, p. 45-48).

In proposing the PCB regulation as it applies to transformers, the Agency weighed all environmental, health, and economic (including energy) factors available to it at the time. In the Preamble to the proposed regulation, the Agency noted a number of areas in which more information relating to these factors would be particularly useful. Largely as a result of data submitted in response to the Agency's request for additional information, a number of modifications to the proposed regulation have been made. These changes include allowing PCB Transformers to be reclassified as PCB-Contaminated Transformers under certain conditions and changing disposal and testing requirements for PCB-contaminated mineral oil. (An extensive discussion of the Agency's rationale is found in the Preamble to the final rule in section II.C, Classification of Transformers Under This Rule.)

Several comments requested that EPA impose a moratorium on adopting the prohibition rule pending further study of economics and acceptable levels of

PCBs in the environment (48, 49, 91, 93, 210, I TR, p. 15).

The Agency is directed by TSCA to implement the bans on PCB activities in keeping with the designated timetables that are contained in the Act. In setting specific dates for the prohibition of PCB activities, Congress intended to give the Agency limited discretion in the timing for implementing the PCB bans.

The proposed five year authorization period for servicing PCB Transformers was strongly objected to by many persons as being too short and therefore unreasonable (11, 17, 20, 31, 32, 35, 37, 42, 53, 58, 71, 85, 88, 104, 156, 199, 210, I TR, p. 17). One comment endorsed the servicing authorization of five years provided the authorization was subject to further renewal (89). One comment recommended shortening the five year authorization period since the criteria in §6(e)(3)(B) of TSCA called for annual exemptions (83). Many comments suggested an authorization should be granted for the useful life of the transformer (17, 36, 37, 54, 70, 82, 98, 156, 178, 189, I TR, p. 17).

The proposed five year authorization for servicing transformers was not intended to signify Agency intent to end those activities after five years. Its purpose was to require a reassessment of the servicing limitation prior to the end of the five year period so that factors such as new servicing technology could be considered in deciding the need for authorizations beyond the initial five year period. Due to the Agency's desire to have exemptions and authorizations expire at the same time, the Agency has changed the five year authorization so that it will expire on July 1, 1984. (This issue is discussed in sections VIII.B and IX.A of the Preamble).

Two persons objected to the differentiation made between exemption requirements for servicing by owners and non-owners (11, 156).

Under §6(e)(3) of TSCA, processing and distribution in commerce of PCBs after July 1, 1979 are not permitted unless an exemption has been granted by EPA. If a person services his own transformer with his own PCBs, processing and distribution in commerce do not occur. However, if one is servicing another's transformer and adds PCBs to that transformer so that title to those PCBs is changed, processing and distribution in commerce occurs. Because TSCA requires an exemption for distribution in commerce after July 1, 1979, the Agency must require a person who adds PCBs to another's transformer to have an exemption after that date.

One person commented that the proposed rule would have a greater impact on small businesses whose sole income comes from the repair of PCB Transformers than it would have on companies such as General Electric and Westinghouse who, in addition to repairing PCB Transformers, also manufacture other electrical articles and equipment (49).

The Agency acknowledges that this regulation could have a greater impact on businesses who have smaller profit margins and less diversified sources of income. However, as one trade association noted, the restriction on the rebuilding of PCB Transformers would affect around only 10% of the total business for small repair companies (VI TR, p. 79). Further, it is reasonable to assume that the loss of this repair activity can be compensated for by expansion into other repair activities.

A large number of persons commenting objected to the prohibition against rebuilding of PCB Transformers (30, 57, 58, 89, 91, 93, 94, 123, 131, 137, 156, III TR, p. 87-88, III TR, p. 124, VI TR, p. 8). A number of comments contended that rebuilding presented no risk to man or the environment (9, 46, 49, 91, 93, 137, 210, I TR, p. 18, III TR, p. 127, IV TR, p. 5, VII TR, p.

53-55). Two comments were received expressing concern for the exposure to workers during the rebuilding of PCB Transformers (53, 74). Three comments recommended that rebuilding be allowed at EPA-approved transformer facilities using EPA standards for the rebuilding activities (17, 48, 74). Three comments stated that they had no serious objections to the restrictions on rebuilding of PCB Transformers (46, 71, VII TR, p. 29).

None of the comments the Agency received presented data that would change EPA's finding that continued rebuilding of PCB Transformers would present an unreasonable risk of injury to human health or the environment. EPA decided to not develop rebuilding standards because they would probably have an unacceptably high economic impact. This issue is discussed further in section IX.A.1, General Discussion of Transformer Servicing, in the Preamble to the rule.

Several persons recommended that EPA either require or at least permit PCB Transformers to be drained, flushed, and refilled with non-PCB fluid, or, on a voluntary basis, be permitted to perform such actions (39, 53, 58, 77, 82, 85, 94, 104, 123, 144, 190, 204, VI TR, p. 162). Three persons stated that acceptable substitutes for PCBs were available for both topping-off and refilling (38, 58, 121). Some comments expressed apprehension about the availability of acceptable substitutes (31, 35, 44, 71, 91, 104, 144, VI TR, p. 59, VII TR, p. 51-52). Others objected to the suggestion that PCB Transformers must be refilled with non-PCB fluid (31, 153). One comment objected to refilling and topping off with non-PCB fluid because it would only add to the amount of material to be disposed of (43).

EPA wishes to note that the use of substitutes for topping off or refilling PCB Transformers is optional. Owners or operators are not precluded from adding a dielectric fluid with greater than 500 ppm PCB to a PCB Transformer. Routine servicing and topping off of PCB Transformers with additional PCBs is not considered a potentially hazardous operation and is consistent with the authorization of continued use of PCB Transformers.

Many of the comments received regarding mineral oil transformers expressed concern that the restrictions on the recycling of PCB-contaminated mineral oil and transformer casings would result in the waste of oil, valuable metals and other natural resources (3, 11, 36, 46, 49, 55, 77, 82, 88, 97, 103, 107, 122, 137, 150, 151, 153, 156, 188, 210). The majority of comments advocated permitting a disposal method, other than high temperature incineration for mineral oil contaminated between 50 and 500 ppm PCB (41, 46, 70, 71, 90, 93, 94, 102, 119).

Most of the persons commenting recommended the use of contaminated mineral oil (mineral oil containing between 50 and 500 ppm of PCBs) as a fuel in electric utility boilers. They argued that this method of disposal had two very positive effects; one, it would reduce the economic costs of disposal, and, two, it would utilize the fuel value of the oil thus reducing the waste of natural resources (4, 28, 36, 37, 46, 58, 72, 88, 97, 100, 103, 111, 134, 144, 145, 147, 151, 156, 172, 190, 198, I TR, p. 142-143, I TR, p. 116, II TR, p. 60, VI TR, p. 46). In addition, several comments were made stating that the scarcity of suitable disposal facilities makes disposal burdensome and costly (11, 37, 46, 77, 82, 87, 88, 102, 156, 165, 172, 188, 201, I TR, p. 156, II TR, p. 60-61). Others argued that the lack of disposal facilities would increase the hazard of environmental contamination created by transporting PCBs long distances to approved facilities and would increase the length of storage time (33, 77, 82, 144, 151, 198, 210). A few comments suggested that contaminated mineral oil should be permitted for reuse as recycled oil or used as a solvent for successive flushings of transformers. This would further reduce the total amount of contaminated mineral oil that will be disposed of, decrease the demand for new mineral oil, and reduce the economic impact of the rule (5, 27, 40, 42, 82, 156, I TR, p. 16). Several comments endorsed the EPA proposal which did not place restrictions on the salvaging of mineral oil transformers once the fluid had been drained from them (40, 94, IV TR, p. 22).

The final rule represents a significant change from the proposal on the disposal requirements for mineral oils contaminated between 50 and 500 ppm PCB. As noted above, a number of comments, particularly from utilities, favored continuation of the existing practice of burning waste mineral oil in power generation boilers. On the basis of our analysis of these comments, the rule has been changed to allow the burning of such oil in high efficiency boilers. A complete discussion on this change is contained in section III.A, Mineral Oil Dielectric Fluid with 50 to 500 ppm PCB, in the Preamble to the rule.

In addition, the final rule allows the disposal of PCB-contaminated mineral oil dielectric fluid and other low concentration PCB liquid wastes in chemical waste landfills. Chemical waste landfills have been shown to be an acceptable technique for disposing of low concentration liquid wastes. These two alternatives will reduce mineral oil disposal costs and lessen the burden on incinerators.

Another area of concern to many of the persons commenting were the testing requirements for mineral oil. The costs of testing were cited as extremely burdensome (31, 35, 37, 49, 80, 83, 90, 91, 94, 100, 103, 108, 111, 113, 122, 137, 144, 145, 146, 147, 165, 176, 189, 201, I TR, p. 136, II TR, p. 51, II TR, p. 5-6). Several alternatives were suggested for dealing with the problems associated with testing mineral oil transformers. The most commonly advocated suggestion was to permit bulk storage and testing of mineral oil for PCB contamination. This method would be preferable because it would substantially reduce the economic burden associated with testing, reduce the likelihood of long delays in obtaining results, and reduce interference in day to day business operation (4, 27, 37, 65, 87, 100, 103, 183, I TR, p. 15-16, I TR, p. 107, I TR, p. 131-132, I TR, p. 138).

Several comments recommended that the requirements for testing of PCBs in non-PCB Transformers be deleted because of high cost (123, 188, VI TR, p. 20). One alternative suggested that EPA exempt mineral oil filled distribution transformers from sampling and analysis for the purpose of labeling and disposal, if the unit was originally a mineral oil transformer and there had been no servicing that would have made contamination possible (88, 108).

Some comments stated that there are not sufficient laboratories qualified to analyze PCBs to meet the demand created in the proposal. They also expressed concern about the divergent results reported by different laboratories analyzing identical samples, and they feared that increased demand would result in the establishment of many unqualified laboratories because EPA has not established testing standards for PCBs (31, 46, 88, 95, 144, 172, 190, 210, II TR, p. 57, I TR, p. 139-140).

The Agency is addressing the issue of testing burdens and costs by allowing persons to assume that mineral oil from mineral oil transformers is contaminated with PCBs between 50 and 500 ppm PCB. This assumption therefore permits these persons to dispose of their mineral oil in high efficiency boilers or chemical waste landfills in addition to the proposed method of disposal in high temperature incinerators. This greatly reduces the need to test mineral oil for PCB concentration. Testing may be desired to determine if the PCB concentration is below 50 ppm in order to use or dispose of the oil with fewer restrictions.

In instances where testing is to be performed, batch testing of the mineral oil is allowable, rather than requiring testing of the oil from each individual transformer. As indicated in comments, batching of mineral oil is common industry practice and the Agency sees little environmental advantage to requiring individual transformer testing. In addition, batch testing will result in additional testing cost savings. (A more complete discussion on transformer testing and batch testing is provided in the Preamble to the rule in section II.C.4.a, Determining Appropriate (Transformer) Categories, and in section III.E, Batch Testing of Mineral Oil Dielectric Fluid, respectively.)

The Agency has responded to the concerns about testing methods and consistent results by adding a new section to the Preamble of the rule, section XII, Test Procedures for PCB, that describes the approach for improving testing results for PCBs.

The disposal and salvage of drained mineral oil transformers are essentially not controlled by this rule, which is unchanged from the proposal.

Several persons requested that EPA revise the rule to deal with mineral oil transformers and equipment under a less restrictive set of rules (46, 97, 134). Others desired that all mineral oil filled transformers be exempted from the rule (4, 87, 147, 189, VI TR, p. 17-18). A few comments recommended that transformers containing mineral oil with less than 500 ppm PCB be excluded from the rule (110, 129, 134, 139, I TR, p. 15). Several comments advocated the partial or total exclusion of certain types of transformers containing less than a certain number of gallons of fluid (83, 147, 156), and one comment was received suggesting that only mineral oil transformers past a certain age should be subject to regulation (11).

No evidence has been presented that would convince EPA to be less restrictive or to exclude certain classes of mineral oil transformers from control under this regulation on the basis of size, age, or manufacturer. None of the comments were able to disprove the Agency's belief that PCB contamination results both from previous manufacturing practices and past and present service practices.

A few comments were received advocating a requirement that all transformers manufactured after January 1, 1979 be labeled "No PCBs" (4, 102, 109, 144). Other comments were received that stated existing marking requirements were sufficient (46, 91, 93, 94).

The marking requirements for PCBs have been modified to reflect EPA's lowering of the applicable PCB concentration to 50 ppm. All containers of PCB-contaminated mineral oil that have 50 ppm or greater of PCBs are required to be marked, but PCB-Contaminated Transformers are not required to be marked since all transformers are either marked as PCB Transformers or are assumed to be PCB-Contaminated Transformers. A more complete discussion of marking changes is contained in the Preamble to the rule; section IV, Changes in Subpart C: Marking of PCBs and PCB Items.

The Agency does not agree with the recommendation to place "No PCBs" labels on transformers manufactured after January 1, 1979 because of the continuing potential to contaminate transformers with PCBs during servicing operations.

One person objected to the proposed 50 ppm cut-off concentration because he thought that regulation of PCB-Contaminated Transformers would create an increased demand for naphthenic oil, a replacement transformer fluid that is in short supply. He thought that the rule would worsen an already critical situation and make it difficult to maintain equipment (88).

The Agency wishes to clarify that this comment presumes that EPA was prohibiting recycling transformer oils containing more than 50 ppm PCB. This is not the case. The Agency, in its authorization for servicing PCB-Contaminated Transformers, permits the recycling of dielectric fluid with less than 500 ppm PCB for use in PCB-Contaminated Transformers. The Agency, aware that the proposal could have been more direct, has made this point more explicitly in the final rule in §761.31(a)(3).

VIII. RAILROADS

A number of comments were made by affected parties that were critical of the Agency's proposal. The Agency proposed that railroad transfomers that use PCB dielectric fluid, reduce the PCB concentration in the dielectric fluid to less than 40,000 ppm PCB at the end of 15 months and to 1,000 ppm at the end of three years. Two commentors indicated that due to the availability of substitutes, the requirements for draining and refilling PCBs for use in this application should be more stringent (53, 85). Other commentors stated that the schedule was too stringent because analysis has not yet been completed on the technical and safety aspects of refilling railroad transformers with non-PCB fluid. Therefore, these persons thought that requirements for refilling transformers in 15 months and restrictions on the allowable residual PCB levels in those transformers should be delayed until that analysis is completed (12, 13, 33, 128, 149, 197). Comments were also submitted which expressed concern that 40,000 ppm PCB (4% on dry weight basis) would be difficult to achieve using standard refilling practices. They recommended a slightly higher level of 6% PCB (33, IX TR, p. 125).

The Agency agrees that additional data on the technical feasibility and safety of potential substitutes used in a refilling program would be extremely useful and has, therefore, postponed the date by which a 1,000 ppm level must be achieved. This delay will allow the railroad industry a reasonable amount of time to complete the study and to reduce their PCB concentrations to a level that will not present an unreasonable risk to health and the environment. In addition, the Agency agrees that routine refilling is not likely to reduce PCB concentrations to 4% PCB and has, therefore, raised the allowable concentration of PCB from four percent to six percent. The rationale for these decisions is discussed in depth in section IX.B of the Preamble.

Some comments were also made urging that the rule not apply to equipment that will be retired as a result of the Northeast corridor power conversion (VIII TR, p. 196, IX TR, p. 159, IX TR, p. 177).

In response to the railroad industry's concern about completing and reviewing the safety study on non-PCB substitution, EPA postponed, as explained above, the date by which the initial refilling was to be completed to January 1, 1982. Originally this coincided with the schedule for the Northeast power conversion. However, recently the Department of Transportation announced that the project will not be completed until the Fall of 1983. Although the date for this initial refilling does not coincide with the new DOT schedule for power conversion, EPA has decided not to again postpone the date because the economic impact of the proposed rule has already been significantly reduced by postponing to January 1, 1982, the date of initial refilling to achieve a 60,000 ppm PCB residual. The PCB concentration in all PCB railroad transformers will have to be further reduced to 1,000 ppm by January 1, 1984.

Since the DOT change-over will not occur until late 1983, almost 90 percent of the time period authorized for operation at 60,000 ppm will be available for the older locomotives before the change-over forces them out of service. This means that the railroads will not have to spend large amounts of capital for PCB reduction and then shortly thereafter phase out the use of the older railroad transformers.

X. HYDRAULIC SYSTEMS

The proposed rule authorized the use and regulated the removal of PCBs from hydraulic die casting systems which are machines used to cast metals under high pressure and are a major source of PCB-contaminated hydraulic fluid. During the comment period the Agency received comments explaining that there are other types of similar hydraulic equipment that are not classified as "die casting" hydraulic equipment but which should logically be treated the same as hydraulic die casting equipment for purposes of this regulation (15, 59, 101).

The Agency agrees with this comment and has, therefore, broadened the applicability of the authorization to cover all hydraulic systems that use PCB-contaminated hydraulic fluid.

Some comments stated that the proposed semi-annual requirements for testing of hydraulic systems and replacement of the fluid were impractical due to testing difficulties and production disruptions (15, 59, 101).

The Agency has taken note of this concern and is now requiring that the system be tested within six months from the effective date of the rule and then only annually thereafter until the PCB concentration is below 50 ppm. Refilling, if required, must take place within six months after testing. This change from semi-annual to annual testing and refilling will be less disruptive as most systems undergo repair or overhaul at least once annually (see section IX.E of the Preamble).

Comments from industry also noted difficulties in reducing the PCB level in a hydraulic system's fluid to less than 50 ppm (15, 101). One non-industrial commentor was critical of the Agency for not requiring reduction of the concentration of PCBs to undetectable levels (V TR, p. 163).

The Agency agrees with this first comment that it would be difficult to reduce PCB levels in hydraulic systems to levels below 50 ppm. Reducing PCB concentrations to 50 ppm would require relatively few flushings; whereas, to achieve and maintain levels substantially below 50 ppm is likely to require a large number of flushings. This is due to the residual levels ot PCBs that are found in most systems that ever used or that were ever contaminated with PCBs and which are likely to recontaminate the purified fluid with minute amounts of PCBs. These residual PCBs are not likely to raise the fluid's PCB concentration to levels above 50 ppm but may raise the PCB concentration from undetectable levels to detectable levels. (For a more extensive discussion of this 50 ppm subject as it relates to all uses of PCBs, see the Preamble to the rule section I.B)

A comment was made that once a hydraulic system is tested and found to contain less than 50 ppm PCB, the Agency's proposed requirement that testing be performed again after at least three months is unnecessary (15). The Agency agrees with this comment and has deleted that requirement.

One comment was received that suggested hydraulic systems of less than 55 gallons not be covered by the rule (15). The commentor stated that since the capacity of systems which hold less than a 55 gallons is small, they have tended to be easier to top and refill in the past and thus are less likely to contain high PCB levels.

The Agency feels that testing is necessary in order that owners of all hydraulic systems that ever contained PCBs accurately determine the PCB levels contained in all their hydraulic systems. In addition, the Agency has no reason to assume that all small hydraulic systems are better maintained than larger systems. The one comment EPA received may not necessarily be representative of all owners of such hydraulic systems.

XI. HEAT TRANSFER SYSTEMS

In the proposed rule, the Agency did not authorize the use or servicing of heat transfer systems [illegible] 50 ppm or greater PCBs. At the time of the proposal, the Agency did not have adequate data on the use of heat transfer systems to propose an authorization. The Agency received very few comments on this use of PCBs.

Two commentors were critical of the Agency's lack of a proposed authorization (81, 116). One commentor, a manufacturer of heat transfer fluids, said that as many as 450 heat transfer systems may have been contaminated with PCBs but that the potential for exposure to PCBs from these systems is low. He said that the pump seal, which is the highest risk area for leakage, is monitored and inspected so that a leak would be rapidly detected (81). The other commentor addressed the need for a servicing authorization for heat transfer systems, noting that the environmental risks presented by continued use and servicing are no greater than for other PCB activities that EPA proposed authorizing (116).

The Agency understands the need for a use and servicing authorization for owners of heat transfer systems. (See section IX.D of the Preamble for a discussion of the Agency's reasons for authorizing this use.) These activities are authorized until July 1, 1984 under the condition that all systems that have ever contained PCBs are tested to determine their current PCB levels. Any system found to contain more than 50 ppm PCB must be drained within six months and refilled with fluid containing less than 50 ppm PCBs. Topping off a heat transfer system with non-PCB fluids can also be conducted to reduce PCB concentrations below 50 ppm. Annual testing will be required until a 50 ppm or less PCB concentration is achieved. The first testing must be by October 1, 1979. This date was chosen on the basis of a commentor's suggestion that considerably more than the 30 days that was proposed would be needed for testing of a hydraulic or heat transfer system (15).

XII. PCB ARTICLES AND PCB EQUIPMENT

A number of commentors (1, 2, 7, 16, 46, 52, 53, 58, 66, 86, 115, 120, 130, 156, 157) contended that the legislative history of §6(e) of TSCA demonstrates that this provision does not give the Agency authority to regulate PCB Articles and PCB Equipment. However, another commentor (182) noted that the legislative history for §6(e) does support such regulation by the Agency.

EPA has reviewed the legislative history of §6(e) in light of the various comments received concerning regulation of PCB Articles and Equipment. The legislative history indicates (1) that the words "polychlorinated biphenyls" as used in §6(e) are intended to include PCB Articles and PCB Equipment and (2) that comprehensive and direct regulation of PCB Articles and Equipment was contemplated. Illustrative material from the legislative history, which has led the Agency to the above conclusions, is given in the following paragraphs.

Although commentors (46, 50) have cited Congressman Gude, they have not cited the following statements by the Congressman. These statements indicate that direct regulation of PCB Articles and Equipment was contemplated under §6(e). Mr. Gude said:

> ...our amendment [on PCB's] does not affect small business except in the handling of articles that have PCBs in them;...
>
> * * *
>
> For example, an electric company must show that continued use of PCB's in transformers is necessary to guarantee safety from fire and that they are making a good faith effort to find substitutes.

122 Cong. Rec. H8830-31 (daily ed., August 23, 1976).

Similarly, Senator Nelson (the Senate sponsor of the PCB amendment) assumed there would be direct regulation of PCB Articles and Equipment under his amendment. He stated:

> ...this [PCB] amendment provides over a period of time the elimination of the use in open or closed systems of PCB's, polychlorinated biphenyls, unless the EPA administrator finds that there is not a serious health hazard.
>
> * * *
>
> Second. The manufacture of all PCBs would be banned effective two years from the date of enactment; and the processing and distribution of all PCBs would be banned six months after that - 2 1/2 years after enactment - unless the administrator finds that no reasonable risk of injury to health or the environment

> is presented by PCBs. This would effectively ban all PCB use, including closed uses, such as in electrical capacitors and transformers.

122 Cong. Rec. S4408 (daily ed., March 26, 1976 with emphasis added). These remarks by Senator Nelson clearly indicate that direct regulation of PCB Articles and Equipment was contemplated.

Senator Nelson's discussion of the labeling and disposal provisions of §6(e) also establishes that regulation of PCB Articles and Equipment was intended. He stated:

> Within 6 months after enactment, EPA is required to issue regulations for the first [requirement], disposal of PCB's and second, labeling with warnings and instructions of all products containing PCB's with respect to their use and disposal.

122 Cong. Rec. S4408 (daily ed., March 26, 1976 with emphasis added). The reference to "products containing PCB's" indicates that PCB Articles and Equipment are to be regulated.

In summary, the legislative history of §6(e) supports and requires direct regulation by the Agency of PCB Articles and PCB Equipment.

XIII. PIGMENTS

In the proposed rule, the Agency redefined the lower concentration of PCB which constitutes a "PCB Mixture" from 500 to 50 ppm. In effect, this would result in a ban on the manufacture, processing, distribution in commerce, and use of PCBs as they appear at 50 ppm or greater. This prohibition includes even those processes which inadvertently produce PCBs in excess of 50 ppm at any step in the manufacturing process.

A number of persons objected to the proposal of lowering the concentration of PCB regulated under this rule because it would cause many pigment manufacturers and processors to close down until process changes could be made. They felt that no one would be able to reduce their concentrations to less than 50 ppm by the effective date of the rule (14, 39W 43, 63, 177, VIII TR, p. 6, p. 106-107, p. 121, p. 125, p. 136, pp. 151). These persons further stated that there currently is no valid method available for determining the concentration of PCBs in certain pigments (14, 43, 118, VIII TR, p. 10, p. 14, p. 105, p. 125, p. 135, p. 150-151) and, therefore, no way of knowing conclusively whether or not they are in conflict with the rule.

To circumvent these problems, a number of persons requested that either the Agency maintain the 500 ppm definition of PCB for the next two years or authorize the pigment industries to manufacture and process PCB contaminated mixtures containing over 50 ppm PCB for the next two years (14, 39, 63, 118, VIII TR, p. 6, p. 44-45, p. 124, p. 137, p. 151). It was thought that this alternative, in comparison to the formal exemption rulemaking process, would be less demanding of administrative resources (VIII TR, p. 21, p. 151). One person (63) suggested that the Agency grant a six month exemption from the ban on distribution in commerce in order to allow suppliers to sell their inventory. In either case they thought that they would need from six months to three years to both develop a valid analytical method for quantifying PCB in pigments and to convert to new technology to reduce or eliminate PCBs from pigments (118, VIII TR, p. 6).

The Agency does not believe that a 500 ppm cut-off concentration is an acceptable alternative because (1) there would be a substantial amount of PCBs between 50 and 500 ppm that would go unregulated and (2) the pigment industry has indicated that it is possible to reduce PCB concentrations in pigments to less than 50 ppm. The Agency believes that the authorization and exemption processes are the most effective way to deal with any difficulties. The authorization and exemption processes allow the Agency to tailor the compliance requirements and to be informed as to which companies are having problems and how they are disposing of their waste streams. (See section IX of the Preamble.)

In this final rule, the Agency has authorized the processing, distribution in commerce, and use of pigments containing PCBs until January 1, 1982. However, persons who manufacture these pigments must petition for an exemption if they want to manufacture pigments containing 50 ppm or more of PCBs after the effective date of this rule. Similarly, persons must file exemption petitions if they wish to process or distribute in commerce pigments which contain 50 ppm or more of PCBs after July 1, 1979.

XIV. PROCESS CONTAMINATION

In the proposed rule, the Agency banned the manufacture of chemicals inadvertently contaminated with PCBs in excess of 50 ppm, including those chemicals that are manufactured for site-limited use. Some persons objected to this ban because (in the absense of exemptions) this would cause some industries to shut down their operations (136, 161, 39) and would unfairly favor foreign products (136). These persons suggested that as alternatives, EPA consider raising the level for controlling PCBs to 500 ppm or specifically exclude unintentionally produced PCBs from the rule (136, 161).

None of these persons provided the Agency with any economic data that allows EPA to determine the magnitude of economic impact of this rule on persons who manufacture chemicals contaminated with PCBs. Because of the substantial amounts of PCBs that are produced in chemicals that contain between 50 and 500 ppm PCB (EPA estimates 100,000 to 500,000 pounds of PCB per year based on data included in exemption petitions), the Agency believes that excluding these chemicals from the rule is not an appropriate alternative. In some cases, more careful quality control of the production operations can reduce or eliminate these PCB impurities. Persons may, however, request an exemption from the January 1, 1979 manufacturing bans and the July 1, 1979 processing and distribution in commerce bans on PCBs. Information submitted in these requests should adequately provide the Agency with the information it needs to determine whether or not such exemption would present an unreasonable risk. (See section VI.C.1 of the Preamble for additional discussion of this process contamination issue).

Two persons (124, 136) commented that the Agency should consider the use of authorities within TSCA other than §6(e) to control inadvertently manufactured PCBs. It was indicated that §6(b) of TSCA was intended to be the appropriate authority to control chemical processes.

The broad coverage of §6(e) indicates that EPA has the authority to control inadvertently manufactured PCBs. Further, although §6(e)(5) gives EPA the prerogative to use other authorities, EPA is not required to use these other authorities. The Agency has reviewed the various regulatory alternatives including TSCA §6(b) and believes that §6(e) is a less cumbersome and more expedient way in which to control inadvertently manufactured PCBs than regulation under other TSCA or EPA authorities.

One person (174) commented that the Agency was improperly using the term "manufacture" by applying it to chemicals manufactured for use as an intermediate. The commentor suggested that the regulation's application be limited to the manufacture of PCBs for distribution in commerce and not for on-site use. This person asserted that the Agency was overextending the accepted definition of an intermediate as established in the inventory rules which defines an intermediate as a chemical substance that is removed from the equipment in which it is manufactured. In addition, this person thought that site-limited intermediates present little, if any, threat to either health or the environment.

The Agency disagrees with this comment. For the purposes of the inventory rule, §710.4(d) excludes certain chemicals from the requirements for reporting, including intermediates which are not removed from the equipment in which they were manufactured. However, such intermediates are still specifically considered to be "manufactured and processed for a commercial purpose" for the purposes of §8 and §6 of TSCA.

The manufacture and processing of chemicals at a site could present exposure problems to workers and the environment. Because of the risks associated with such exposure to PCBs, the rule prohibits all manufacturing and processing and does not exempt "site limited" activities. This is in keeping with the inventory rule which requires persons to identify those intermediates which have site-limited use.

XV. ELECTROMAGNETS

The Agency has become aware that PCBs have also been used in large electromagnets that are designed to remove tramp iron from non-magnetic commodities such as coal and grain. One person stated that he did not see any significant difference between the environmental threat of an electromagnet and an askarel transformer and suggested that they be handled similarly (X TR, p. 165). Other persons stated that their electromagnets are enclosed in a solid steel casing and have never experienced failure in their many years of use (137, 31).

The Agency agrees that use of PCBs in intact, non-leaking electromagnets are like transformers that are used in a totally enclosed manner. Electromagnets are constructed such that the PCBs are enclosed in completely welded structures and, historically, have been subject to few leakages. Therefore, use of these electromagnets is permitted; however, like transformers, rebuildings of electromagnets is not permitted. (See section IX.H of the Preamble for additional discussion.)

XVI. MICROSCOPY

Historically, there have been three uses for PCBs in the field of microscopy. The first application is the use of PCBs as an immersion oil. The second microscopic application is the use of PCBs as a refractive index oil. The third application is the use of PCBs as a mounting medium. This technique is particularly important to scientists who need to preserve, for future reference, a microscopic sized particle. According to one person (76), it is also used in air pollution and criminology labs for particle identification. In the mounting medium method, PCBs are used as the medium in which the particle is placed and covered with a glass slip usually for permanent reference.

During the PCB Ban Hearing representatives from the field of microscopy agreed that of the three microsopic uses, use as a mounting medium is the only application for which PCBs are essential (X TR, p. 13, p. 50-51, p. 65-66, p. 69-70). All the microscopists indicated that suitable substitutes for PCBs as an immersion oil and as a refractive index oil exist (10, X TR, p. 18, p. 74, p. 76). However, there are currently no substitutes for PCBs as a mounting medium with the desirable physical properties that characterize PCBs (10, X TR, p. 18, p. 87). In addition, these persons stated or implied that extremely small quantities of PCBs are used for each application and, over time, the total quantities used are also small (127, X TR, p. 5, p. 46-47). Some persons recommended that EPA require special protective garments, vapor hoods, and instructions and training in handling and disposal for these PCB uses (23, X TR, p. 26-28; p. 90). These recommendations however were challenged by other participants at the hearing. At least one person pointed out that the use of a fume hood would create a problem because of the likelihood that the air movement may cause the loss of the particle being studied (X TR, p. 46). It was also pointed out that a substantial amount of exposure to PCBs has been minimized because of the extremely high viscosity of Aroclor 5442 which aids in preventing spillage (X TR, p. 28) and the extremely small amounts of PCBs which are used (76, X TR, p. 46, p. 60). Further, it appears from the comments at the hearings that meticulous and careful procedures are typical because of the nature of laboratory work (X TR, p. 27, p. 46, p. 59).

The Agency believes that exposure to PCBs used as a mounting medium will be minimal because of the small amounts that are used at any one time and the careful nature of the work. For these reasons and because no one presented any convincing evidence indicating that the risk from the use of PCBs as a mounting medium outweighs the benefits, the Agency has decided to authorize this processing, distribution in commerce, and use until July 1, 1984; however, after July 1, 1979 persons will have to obtain an exemption to process and distribute in commerce PCBs for microscopy.

XVII. WASTE OIL

The Agency proposed prohibiting the use of used ("waste") oil containing any detectable amount of PCB as a sealant, coating, or dust control agent. It was understood that the use of waste oil as a dust control agent is widespread on unpaved roadways. Few comments were received on the proposal and its impact on road oiling.

One environmental group commented favorably upon the proposed ban of this activity, citing potential widespread environmental and human exposure to PCBs resulting from this use of waste oil (85). Another commentor cited a lack of substitutes for waste oil on uncovered roadways other than paving, which he characterized as expensive, or watering, which he said is less efficient (15). One manufacturer of a substitute for waste oil that is used to control dust commented about the advantages of his product over waste oil with respect to both cost and performance (217).

The Agency agrees that use of PCBs as sealants, coatings, and dust control agents provides a direct route for entry of PCBs into the environment. Further, it is the Agency's understanding that substitutes for PCBs as a dust control agents are available. In the absence of any convincing data to the contrary, the Agency has decided to maintain its ban on these uses. For a more detailed discussion of this determination, see section VI.A.1 of the Preamble.

XVIII. NATURAL GAS COMPRESSORS

The proposed rule contained no authorization for the use or servicing of PCB-containing natural gas compressors since, at the time of proposal, the Agency had virtually no knowledge of this application of PCBs. During the comment period, a few persons submitted comments indicating that PCBs were used in compressors in natural gas pipelines. One of the commentors cautioned EPA that the implementation of the 50 ppm cut-off concentration for the regulation of most uses of PCBs could impact the nation's ability (1) to maintain its productive capacity and (2) to assure an adequate, clean fossil energy supply at a reasonable cost (29). Because natural gas systems are not designed with backup compressors, any unscheduled or extended loss of compression decreases the capacity of the system, exacerbating the present natural gas shortage. This person noted that the economic impact of reduced gas quantities was not evaluated in the economic study entitled Microeconomic Impacts of the Proposed PCB Ban Regulation.

Another person indicated that the ban on the use of articles contaminated with 50 ppm PCB or greater, although originally appearing to be burdensome, will now cause him little economic impact (138). He stated that, by the effective date of the regulation, his company will be able to achieve a sufficiently low concentration of PCBs in the lubricants by flushing the system one additional time.

The Agency has considered these comments and the potential energy and economic impacts of an immediate ban on the use and servicing of PCB-containing natural gas compressors. The final rule authorizes the use of PCBs above 50 ppm in natural gas compressors until May 1, 1980. The Agency believes that by this date owners and operators will have had sufficient time to drain, flush, and replace the compressors' fluid so that the fluid will contain PCBs below 50 ppm. A more in-depth discussion of the Agency's rationale for this use is found in section IX.I of the Preamble.

XIX. REVISED VERSAR REPORT

The study entitled Microeconomic Impacts of the Proposed PCB Ban Regulations (the proposed Versar Report) was made available in May 1978 as part of EPA's Draft Support Document for the proposed PCB ban regulation. As a part of the Final Support Document for the final regulation, EPA requested Versar to revise the Versar Report to reflect data submitted in comments and at the informal hearing on the proposed PCB rule.

By letter dated September 1, 1978, Electronic Industries Association (EIA) sought to reopen the comment period for comment on the then unwritten Revised Versar Report. EPA, however, did not reopen the comment period. The Agency responded to the EIA request by letter dated December 13, 1978, stating (1) that EPA had already extended the comment period from September 15, 1978 to October 10, 1978 and (2) that the PCB rulemaking had to be brought to a close in view of the deadlines imposed by §6(e) of TSCA for the regulation of PCBs. The Agency also noted that the nature of the Revised Versar Report does not require reopening of the comment period. EPA stated:

> The purpose of the revised Versar Report is to determine the economic impact of the expected PCB ban regulation in light of the facts submitted at the informal

> hearing (including the prior Versar Report) and in comments. This does not constitute an action which would call for reopening of the record. See e.g., International Harvester Company v. Ruckelshaus, 478 F.2d 615, 632 n. 51 (D.C. Cir. 1973).

The letter was from Peter P. Principe, Chairman of PCB Hearing Panel to Steven S. Rosenthal, attorney for Electronic Industries Association dated December 13, 1978.

EIA renewed its request for an extension of the comment period by letter from Mr. Rosenthal dated December 19, 1978. EPA is treating this letter as a comment and reiterates its response made to EIA by letter on December 13, 1978. As earlier stated, the purpose of the Revised Versar Report is to incorporate economic data supplied in written comments and at the informal hearing into the Versar Report which was previously prepared for the proposed rule. Revisions of this nature by a contractor do not require reopening of the comment period. Accordingly, EPA has not reopened the comment period.

The National Academy of Sciences has developed a draft report entitled, Polychlorinated Biphenyls, which includes sections on economic analysis of PCB control strategies. This draft report was not used by the Agency in the development of the final PCB rule because the report was only in draft form and not available for citation. Since the EPA was under a statutory deadline to promulgate the PCB rules, the Agency chose not to wait for an opportunity to consider the final report.

Appendix I: LIST OF MAJOR COMMENTS

Main Comments

1. Advance Transformer Co.
2. Air-Conditioning and Refrigeration Institute
3. Alabama Power Co.
4. Allegheny Power Service Corp.
5. Allied Chemical Corp.
6. The Aluminum Association, Inc.
7. Amana Refrigeration, Inc.
8. AMAX Environmental Services, Inc.
9. American Electric Apparatus Repair Corp.
10. American Institute for Conservation of Historic and Artistic Works
11. American Public Power Association
12. American Public Transit Association
13. AMTRAK
14. Apollo Colors, Inc.
15. Armco Steel Corp.
16. Association of Home Appliances Manufacturers
17. Atlantic City Electric Co.
18. Baltimore Gas and Electric Co.
19. Bartlett, Louise
20. Bethlehem Steel Corp.
21. Boston Edison Co.

22. Brown Co.
23. Center for Occupational Hazards, Inc.
24. Central Vermont Public Service Corp.
25. Chemetron Pigments Corp.
26. Chemical Waste Management Limited
27. Cincinnati Gas and Electric Co.
28. Cleveland Electric Illuminating Co.
29. Columbia Gas System Service Corp.
30. Columbus and Southern Ohio Electric Co.
31. Commonwealth Edison Co.
32. Consolidated Edison Company of New York, Inc.
33. Consolidated Rail Corp.
34. Consumers Power Co.
35. Dayton Power and Light Co.
36. Department of Water and Power of the City of Los Angeles
37. Detroit Edison
38. Dow Corning Corp.
39. Dry Color Manufacturers Association
40. Duke Power Co.
41. E.I. DuPont de Nemours and Co.
42. Duquesne Light Co.
43. Dyes Environmental and Toxicology Organization, Inc.
44. Eastern Iowa Light and Power Corp.
45. Eastern Utilities Associates

46. Edison Electric Institute
47. Edison Sault Electric Co.
48. Electric Equipment Co.
49. Electrical Apparatus Service Association, Inc.
50. Electronics Industries Association
51. Ellish, Andrew
52. Emerson Quiet Kool Co.
53. Environmental Defense Fund
54. EUA Service Corp.
55. Florida Public Utilities Co.
56. Ford Motor Co.
57. Fort Howard Paper Co.
58. General Electric Co.
59. General Motors Corp.
60. GPU Service Corp.
61. A.P. Green Refractories Co.
62. Gulf Power Co.
63. Harmon Colors Corp.
64. Hartzler, Emma
65. Hawaiian Electric Co., Inc.
66. Honeywell Information System Inc.
67. Iliff, George W.
68. International Business Machines
69. Interstate Power Co.
70. Iowa-Illinois Gas and Electric Co.

71. Iowa Power and Light Co.

72. Iowa Public Service Co.

73. Joy Manufacturing Co.

74. Kiggans, Michael

75. Loup Power District

76. Walter C. McCrone Associates, Inc.

77. Mead Corp.

78. Middle South Services Inc.

79. Minnesota Pollution Control Agency

80. Minnkota Power Cooperative, Inc.

81. Monsanto Co.

82. National Electrical Manufacturers Association

83. National Rural Electric Corporative Association

84. National Wildlife Federation

85. Natural Resources Defense Council, Inc.

86. NCR Corp.

87. Nebraska Power Industry Committee

88. Nebraska Public Power District

89. NEGEA Service Corp.

90. New England Power Co.

91. New York Power Pool

92. New York State Department of Environmental Conservation

93. Niagara Mohawk Power Corp.

94. Northeast Utilities

95. Northern States Power Co.

96. Ohio Edison Co.
97. Ohio Transformer Corp.
98. Olin Corp.
99. Omaha Public Power District
100. Otter Tail Power Co.
101. Outboard Marine Corp.
102. Pacific Gas and Electric Co.
103. Penelec-GPU
104. Phillips Petroleum Co.
105. Phthalchem Inc.
106. Pope Chemical Corp.
107. Port Authority of New York and New Jersey
108. Public Service Company of Colorado
109. Public Service Company of New Hampshire
110. Public Service Electric and Gas Co.
111. Public Service of Indiana
112. Public Utility District No. 1 of Okanogan County
113. Puget Sound Power and Light Co.
114. RADCO Industries, Inc.
115. RCA Corp.
116. Reynolds Aluminum
117. Reynolds Tobacco Co.
118. Ridgeway Color and Chemical Co.
119. Rochester Gas and Electric Corp.
120. Rockwell International

121. RTE Corp.

122. Salt River Project

123. San Antonio, Texas, City of Public Service Board of

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EPA 230-03/79-001

PCB MANUFACTURING, PROCESSING, DISTRIBUTION IN COMMERCE, AND USE BAN REGULATION:

ECONOMIC IMPACT ANALYSIS

MARCH 1979

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PLANNING AND MANAGEMENT
WASHINGTON, D.C. 20460

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EPA 230-03/79-001

PCB MANUFACTURING, PROCESSING, DISTRIBUTION IN COMMERCE, AND USE BAN REGULATION:

ECONOMIC IMPACT ANALYSIS

Final Report

Submitted to:

U.S. Environmental Protection Agency
Office of Planning and Management
Washington, D.C.

Attention: Mr. Stephen R. Weil
Project Officer

Contract No. 68-01-4771

March 30, 1979

This report has been reviewed by the Office of Planning and Management, U.S. Environmental Protection Agency, and approved for publication. Approval does not necessarily signify that the contents reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

PREFACE

This report was prepared by Versar, Inc., for the Office of Planning and Management of the U.S. Environmental Protection Agency. The report summarizes Versar's estimates of the probable costs and impacts of complying with the PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation - 40 CFR Part 761. This regulation implements the requirements of Sections 6(e)(2) and 6(e)(3) of the Toxic Substances Control Act.

Versar's analysis of the economic impacts of the proposed PCB Ban Regulation was summarized in the report "Microeconomic Impacts of the Proposed 'PCB Ban Regulations'" dated May 16, 1978. The promulgated regulations incorporate a significant number of changes that were made to the proposed regulations. In addition, considerable additional information on the economic impacts of the regulation has been added to the rulemaking record as the result of written comments on the proposed regulation and two weeks of public hearings. This report is a revision of the report on the proposed regulations and is based on the promulgated regulations and the information available from the rulemaking record.

This revised report was prepared by Mr. Robert A. Westin, Principal Investigator, and Mr. Bruce Woodcock. Assistance in the handling of data and the preparation of final copy was provided by Ms. Juliet Ballance and Mrs. Rebecca Brown of the Versar staff. Special acknowledgement is given to the close support received from Mr. Stephen R. Weil, EPA Project Officer, and Mr. Steven B. Malkenson who was the EPA Project Officer during the preparation of early drafts of this report.

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1.0 INTRODUCTION

1.1 History of PCB Use

Commercial PCBs are manufactured by the direct chlorination of the chemical "biphenyl." The result of this reaction is a mixture of chlorinated biphenyl molecules that differ in the number and arrangement of chlorine atoms attached to the biphenyl rings. The final product may contain between 21% and 68% chlorine by weight, depending on the amount of chlorine introduced to the reaction vessel. PCBs, therefore, are mixtures of various kinds of polychlorinated biphenyls.

The first commercial production of PCBs in the United States was in 1929. Almost all of the PCBs that have been produced in the U.S. were manufactured by Monsanto Industrial Chemicals Company which marketed various mixtures under the trade names Aroclor® 1016 and Aroclor® 12xx, with the last two digits denoting the average percent chlorine in the mixture. The commercial PCBs varied from Aroclor® 1221 (similar in physical properties to a light oil) to Aroclor® 1268 (a waxy solid). Monsanto also used PCBs in some commercial products formulated for specific purposes, including certain types of Pydraul® hydraulic fluids, Therminol® heat transfer fluids, Turbinol® compressor fluids, and Santovac® vacuum pump fluids. In addition, Monsanto produced various mixtures of polychlorinated terphenyls (PCTs), all of which contained up to 1% PCBs as unintentional byproducts. The PCTs were marketed under the trade name Aroclor® 54xx, with the final digits again denoting the average chlorine content. The PCTs were also marketed as constituents of some Pydraul® hydraulic fluids (Versar, 1976a).*

PCBs in general were noted for their excellent chemical stability, low solubility in water, and low price. The various commercial mixtures covered a wide range of viscosities, melting points, and boiling points and were used in a number of applications including as a plasticizer for plastics, paints, and caulking compounds; as a dielectric liquid in electrical transformers, motors, electromagnets, and capacitors; as a dye carrier in certain carbonless copy papers and printing inks; and as an additive to certain greases, lubricating oils, casting waxes, hydraulic fluids, heat transfer liquids, compressor liquids, and vacuum pump liquids. The various uses of PCBs were described in a report published in early 1976 (Versar, 1976a); estimated use of PCBs in each application and the present environmental distribution of the PCBs are summarized in Table 1.1-1.

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*Versar, Inc., 1976a. PCBs in the United States: Industrial Use and Environmental Distribution, Springfield, Va.: National Technical Information Service (NTIS PB 252-012/3WP), February, 1976.

PCBs were not generally recognized as being toxic until after the occurrence in 1968 of widespread poisoning in Japan caused by the accidental introduction of PCBs into cooking oil. The resulting acute symptoms became known as "Yusho" disease, and it affected 1291 people*. In 1969, analytical procedures were developed that enabled PCBs to be identified in concentrations of parts per million in environmental samples. In 1970, PCBs were identified as the contaminant in coho salmon from Lake Michigan that had affected the reproduction rate of commercial mink fed contaminated fish. The mink reproductive problems had first been reported in 1965; identification of PCBs as the cause awaited development of satisfactory analytical procedures (Stendell, 1975).**

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*For a comprehensive review and discussion of the literature describing the toxicity of PCBs and the details of the YUSHO incident, see: NIOSH, Criteria for a Recommended Standard....Occupational Exposure to Polychlorinated Biphenyls (PCBs), Washington, D.C.: U.S. Government Printing Office, 1977, pp.40-49.

**Stendell, Ray C. 1975. "Summary of Recent Information Regarding Effects of PCB's on Birds and Mammals" in Conference Proceedings, National Conference on Polychlorinated Biphenyls, November 19-21, 1975, Chicago, Illinois. Washington, D.C.: Office of Toxic Substances, U.S. Environmental Protection Agency (Report No. EPA-560/6-75-004).

In 1972, Monsanto voluntarily restricted the sale of PCBs to the manufacture and maintenance of electrical transformers and capacitors and introduced the product Aroclor® 1016 as a more biodegradable dielectric liquid for use in capacitors (Wood, 1975).* Monsanto then contacted their customers to recommend that heat transfer systems containing PCB based Therminol® fluids be drained, flushed, and refilled with non-PCB liquids and that hydraulic systems containing PCB based Pydraul® fluids be topped off as required with compatible non-PCB liquids (Versar, 1978, p. 75).**

Following Monsanto's action in 1972, the only U.S. production of PCBs for "open" system use was by Geneva Industries which manufactured about one million pounds of PCB based heat transfer liquid between 1972 and 1974 (Versar, 1978, p. 4). PCBs were also imported after 1972 for use in maintaining electric motors in certain coal mining machines, and for use in some types of investment casting waxes.

1.2 Regulatory Action on PCBs

In 1973, the U.S. Food and Drug Administration (FDA) established temporary tolerances for PCBs in food, and FDA surveillance resulted in the rejection of numerous lots of fish and occasional lots of chickens and eggs (FDA, 1973).*** By 1975, there was significant evidence of PCBs in industrial effluents and in the environment, and reports of PCB contamination were being featured in the non-technical press. On March 26,

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*Wood, David (Monsanto). 1975. "Chlorinated Biphenyl Dielectrics, Their Utility and Potential Substitutes" in Conference Proceedings, National Conference on Polychlorinated Biphenyls, November 19-21, 1975, Chicago, Illinois Washington, D. C. : Office of Toxic Substances, U.S. Environmental Protection Agency (Report No. EPA-560/6-75-004) pp. 317-322.

**Versar, Inc. 1978. Microeconomic Impacts of the Proposed 'PCB Ban Regulations' (EPA 560/6-77-035), Springfield, Va.: National Technical Information Service (NTIS PB 281-881/3WP). May, 1978.

***FDA. 1973. "Polychlorinated Biphenyls - Contamination of Animal Feeds, Foods, and Food Packaging Materials," Federal Register, July 6, 1973, pp. 18096-18103.

1976, Senator Gaylord Nelson of Wisconsin introduced into the Senate an amendment to the Toxic Substances Control Act (TSCA) that required the eventual elimination of the use of PCBs in the United States. This amendment was the basis of Section 6(e) of TSCA (Figure 1.2-1), and the eventual ban on the manufacture of PCBs became a legislated requirement on October 11, 1976, when TSCA was signed into law.

Concurrent with the consideration of the PCB amendment to TSCA, the EPA proposed toxic pollutant effluent standards for PCBs under Section 307(a) of the Federal Water Pollution Control Act (EPA, 1976).* This proposed regulation would have imposed severe limitations on PCB discharges by capacitor and transformer manufacturers who used PCBs. Following extensive hearings, the PCB effluent standard was promulgated on February 2, 1977 (EPA, 1977d).** The regulation required that all PCB manufacturers and those transformer manufacturers and capacitor manufacturers using PCBs eliminate PCBs from their effluent water by February 2, 1978. The one-year compliance deadline for manufacturers of electrical equipment was established to enable plants to phase out the use of PCBs, convert to substitutes, make appropriate technological or process changes, or take such other steps as necessary to achieve compliance.

Section 6(e) of the Toxic Substances Control Act (TSCA) required the EPA to regulate the marking and disposal of existing PCBs. The manufacture of PCBs and their handling and use in other than a totally enclosed manner was banned effective January 1, 1978. The act also completely banned the manufacture of PCBs after January 1, 1979, and their distribution in commerce effective July 1, 1979. Finally, the act authorized the EPA to grant exemptions and authorizations under certain conditions.

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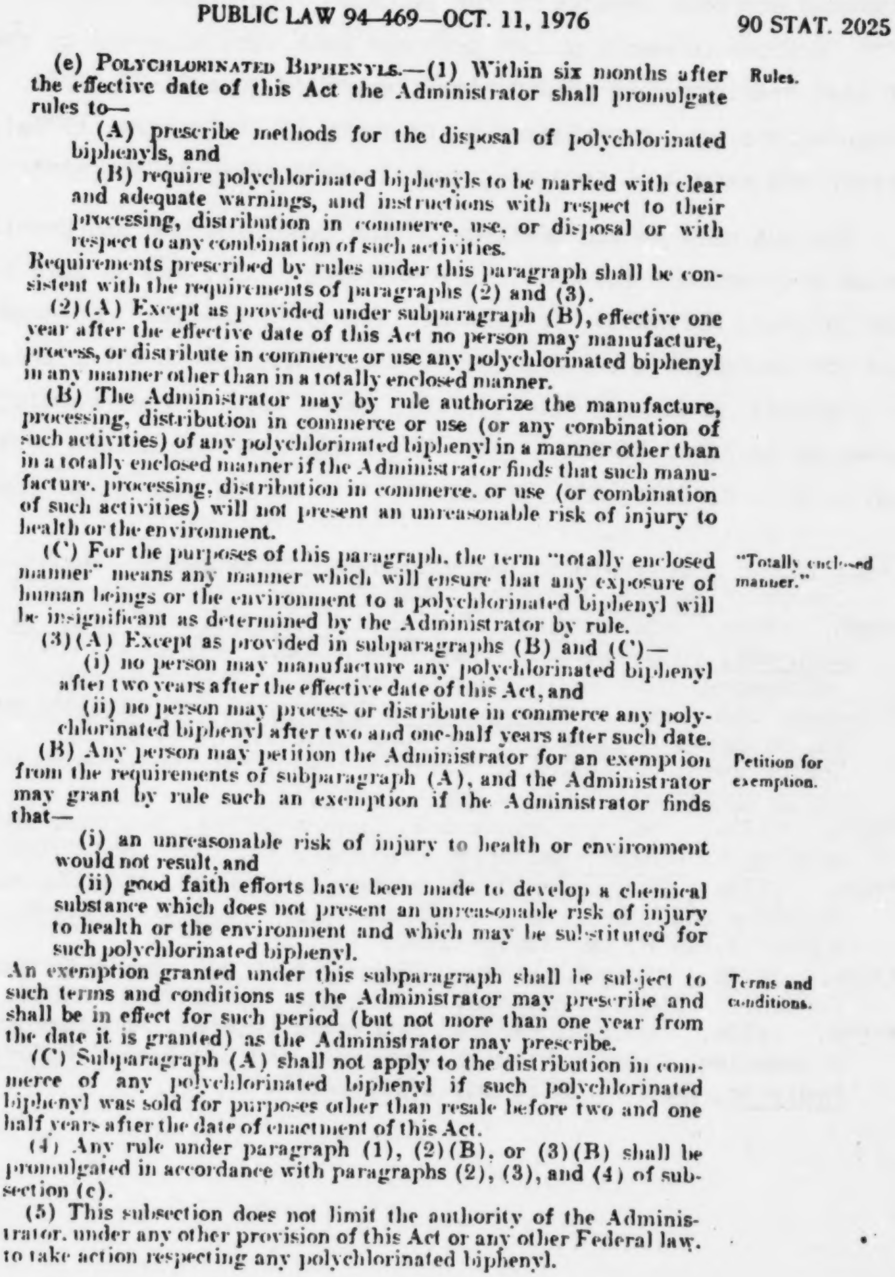
*EPA. 1976. "Water Program - Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls," Federal Register, July 23, 1976, pp. 30468-30477.

**EPA. 1977d. "Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls (PCBs): Final Decision," Federal Register, February 2, 1977, pp. 6531-6555.

Figure 1.2-1

Section 6(e), Toxic Substances Control Act



PUBLIC LAW 94-469—OCT. 11, 1976 90 STAT. 2025

(e) Polychlorinated Biphenyls.—(1) Within six months after the effective date of this Act the Administrator shall promulgate rules to— Rules.

(A) prescribe methods for the disposal of polychlorinated biphenyls, and

(B) require polychlorinated biphenyls to be marked with clear and adequate warnings, and instructions with respect to their processing, distribution in commerce, use, or disposal or with respect to any combination of such activities.

Requirements prescribed by rules under this paragraph shall be consistent with the requirements of paragraphs (2) and (3).

(2)(A) Except as provided under subparagraph (B), effective one year after the effective date of this Act no person may manufacture, process, or distribute in commerce or use any polychlorinated biphenyl in any manner other than in a totally enclosed manner.

(B) The Administrator may by rule authorize the manufacture, processing, distribution in commerce or use (or any combination of such activities) of any polychlorinated biphenyl in a manner other than in a totally enclosed manner if the Administrator finds that such manufacture, processing, distribution in commerce, or use (or combination of such activities) will not present an unreasonable risk of injury to health or the environment.

(C) For the purposes of this paragraph, the term "totally enclosed manner" means any manner which will ensure that any exposure of human beings or the environment to a polychlorinated biphenyl will be insignificant as determined by the Administrator by rule. "Totally enclosed manner."

(3)(A) Except as provided in subparagraphs (B) and (C)—

(i) no person may manufacture any polychlorinated biphenyl after two years after the effective date of this Act, and

(ii) no person may process or distribute in commerce any polychlorinated biphenyl after two and one-half years after such date.

(B) Any person may petition the Administrator for an exemption from the requirements of subparagraph (A), and the Administrator may grant by rule such an exemption if the Administrator finds that— Petition for exemption.

(i) an unreasonable risk of injury to health or environment would not result, and

(ii) good faith efforts have been made to develop a chemical substance which does not present an unreasonable risk of injury to health or the environment and which may be substituted for such polychlorinated biphenyl.

An exemption granted under this subparagraph shall be subject to such terms and conditions as the Administrator may prescribe and shall be in effect for such period (but not more than one year from the date it is granted) as the Administrator may prescribe. Terms and conditions.

(C) Subparagraph (A) shall not apply to the distribution in commerce of any polychlorinated biphenyl if such polychlorinated biphenyl was sold for purposes other than resale before two and one half years after the date of enactment of this Act.

(4) Any rule under paragraph (1), (2)(B), or (3)(B) shall be promulgated in accordance with paragraphs (2), (3), and (4) of subsection (c).

(5) This subsection does not limit the authority of the Administrator, under any other provision of this Act or any other Federal law, to take action respecting any polychlorinated biphenyl.

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Regulatory implementation of the various requirements of Section 6(e) of TSCA has occurred in several steps. EPA proposed regulations on the marking and disposal of PCBs on May 24, 1977 (EPA, 1977a),* and made available a support document (EPA, 1977c)** and a contractor's report on the estimated economic impacts of the proposed regulations (Versar, 1977).*** Written comments on the proposed rule were accepted by the EPA and informal hearings were held during the period June 24-29, 1977. The final regulations were promulgated on February 17, 1978 (EPA, 1978a),**** and corrections were published on August 2, 1978 (EPA, 1978b).*****

The EPA held public meetings on the remaining use ban provisions of Section 6(e) on July 15, 1977, in Washington, D.C., and on July 19, 1977, in Chicago, Illinois. On December 30, 1977, the EPA announced that it would not implement the ban on activities conducted in other than a totally enclosed manner (Section 6(e)(2)) until after formal regulations were promulgated (EPA, 1977b).****** These use ban regulations were proposed on June 7, 1978 (EPA, 1978e).******* At the same time, the EPA made available a support document (EPA, 1978c)* and a contractor's report on the estimated economic impacts (Versar, 1978). In the preamble to the proposed regulation, the EPA asked for written comments on specific technical aspects of the regulation. Written comments were accepted until the start of the hearings which were held in Washington, D.C., from August 21 through September 1, 1978. Opportunity for cross examination of the EPA economics contractor was granted to the Edison Electric Institute and the Electronic Industries Association on September 26, 1978, and reply comments on the proposed regulation were accepted for one week after that date.

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*EPA 1977a. "Polychlorinated Biphenyls (PCBs), Toxic Substance Control," Federal Register. May 24, 1977, pp. 26564-26577.

**EPA. 1977c. PCB Marking and Disposal Regulations - Support Document, (OTS-068005) Washington, D.C.: Office of Toxic Substances, U.S. Environmental Protection Agency, undated.

***Versar, Inc. 1977. Microeconomic Impacts of the Proposed Marking and Disposal Regulations for PCBs (EPA 560/67-77-013), Springfield, Virginia: National Technical Information Service, (NTIS PB 267-833/2WP), April, 1977.

****EPA. 1978a. "Polychlorinated Biphenyls (PCBs), Disposal and Marking." Federal Register. February 17, 1978, pp. 7150-7164.

*****EPA. 1978b. "Polychlorinated Biphenyls (PCB's), Addendum to Preamble and Corrections to Final Rule." Federal Register. August 2, 1978, pp. 33918-33920.

******EPA. 1977b. "Polychlorinated Biphenyls (PCBs), Toxic Substance Control." Federal Register. December 30, 1977, p. 65264.

*******EPA. 1978e. "Polychlorinated Biphenyls (PCB's), Manufacturing, Processing, Distribution in Commerce, and Use Bans," Federal Register, June 7, 1978, pp. 24802-24817.

Versar's previous report on the economic impact of the PCB Ban Regulations (Versar, 1978) was based on the proposed regulations and the data available in May 1978. EPA has since considered several hundred written main comments and reply comments and the information presented at ten days of informal hearings and has revised many of the details of the proposed regulations. The information presented to the EPA since the regulations were proposed has also significantly augmented the data available to Versar. The purpose of this report is to revise the economic analysis performed in May, 1978, to reflect the changes in the regulation and to incorporate additional information (1) that has been made available to the EPA as a result of the rulemaking, and (2) that has been included in the rulemaking record.

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*EPA. 1978c. Office of Toxic Substances. Support Document/Draft Voluntary Environmental Impact Statement for Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation (Section 6(e) of TSCA). Washington, D.C.: U.S. Environmental Protection Agency. May 1978.

2.0 METHODOLOGY FOR ECONOMIC IMPACT ANALYSIS OF THE PCB BAN REGULATIONS

2.1 General Approach

Section 6(e) of the Toxic Substances Control Act (TSCA) established specific dates for the banning of activities involving the manufacture, processing, distribution in commerce, and use of PCBs. TSCA also authorized the EPA to grant exemptions from the rule or to authorize specific activities that would otherwise be banned. These exemptions and authorizations may be granted only if the EPA makes a formal finding that the activities "do not present an unreasonable risk of injury to health or the environment."

If the EPA had not promulgated the PCB ban regulations, the requirements of TSCA could have taken full effect on the dates specified in the act. The effect of the discretionary actions that the EPA has taken by promulgating the regulations is to reduce the economic impact of the legislated requirements in certain cases.

Since the EPA defined in the regulation those materials and manufactured products that are subject to the legislated requirements, it is difficult to separate the economic consequences of the act from the economic impact of the regulation. Calculation of total economic impacts is further complicated by the compliance actions taken by industry in anticipation of the regulations.

This analysis is limited to impacts expected to result from the PCB ban regulations. These impacts are the incremental changes from a base condition assumed to be the industry practices in 1975 as modified by the PCB effluent standards and by the PCB Disposal and Marking Regulations. Increased industry costs caused by the use of substitutes for PCBs and the resulting product development costs or the costs of discontinuing certain products are the basis of the calculation of cost impacts. Each affected industry is considered separately, and long-term economic impacts are calculated by predicting long-term practices and comparing the resulting costs to those that would have been incurred under the base period conditions. Transitional costs are also calculated where there will be a significant capital investment required to comply with the ban regulations or where there will be a prolonged period of adjustment of industrial practices. The economic impact analysis is limited to directly affected industries and to their suppliers and customers. The analysis does not evaluate (1) minor secondary impacts and ripple effects of the regulations, (2) benefits to health or the environment from the ban, or (3) the extent to which exemptions that may be granted by the EPA will reduce these costs.

In general, the methodology used to estimate the economic impacts of the PCB Ban Regulations is the same as that used in previously published studies of the economic impacts of the Proposed PCB Ban Regulations (Versar, 1978), of the Proposed PCB Marking and Disposal Regulations (Versar, 1977), and of the Proposed PCB Effluent Standards (Jack Faucett Associates, 1976).* All of the cited economic impact studies, including this one, have been limited to an evaluation of the costs of the regulations.

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*Jack Faucett Associates, Inc. 1976. Economic Analysis of Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls: Transformer, Capacitor, and PCB Manufacturers (EPA 230/1-76-008), Washington, D.C.: Office of Water Planning and Standards, U.S. Environmental Protection Agency. October 1976.

2.2 Data Base for Economic Impact Analysis

This report's analysis of the economic impacts of the final PCB Ban Regulations is based on the following data:

- Published reports as referenced in the Official Record of rulemaking including the previous Versar report "Microeconomic Impacts of the Proposed 'PCB Ban Regulations'" (Versar, 1978).
- Written comments on the Proposed PCB Ban Regulations received by EPA and made part of the official record of rulemaking.
- Oral comments presented at the public hearings on the proposed rule (August 21 through September 1, 1979). Verbatim transcripts of these hearings are part of the official record of rulemaking.
- Reply comments on the proposed rule received by EPA subsequent to August 21, 1978, and made part of the official record.
- Information on the sampling protocols used by utilities in selecting oil filled transformers to be tested for the presence of PCBs. This information was obtained by Versar through phone conversations with representatives of companies that presented data on the extent of PCB contamination of transformer oil in their written or oral comments on the proposed regulation.

3.0 IMPACT OF BAN ON THE DISTRIBUTION OF PCB CAPACITORS AND EQUIPMENT

3.1 Present Status

3.1.1 PCB Capacitors

The use of PCBs in small capacitors has been gradually phased out over the past two years. Although several manufacturers were using PCBs in at least a portion of their 1978 production of small capacitors, most capacitors manufactured during 1978 do not use PCBs. Most small capacitors are used in the manufacture of new appliances and lighting fixtures; the use of capacitors as repair parts accounts for a comparatively small percentage of the total demand for these items.

Emerson Quiet Kool Company estimated that it would have an inventory of approximately 30,000 PCB capacitors as of January 1, 1979, and that this inventory would represent an investment of $120,000.* Advance Transformer estimated that they might have 100,000 PCB capacitors in inventory on January 1, 1979, that were not built into ballasts or other equipment.** It is not possible to extrapolate this data to an estimate of the total inventories of capacitors that may remain unused on July 1, 1979. If each company normally carries a two-month inventory of capacitors and if only ten percent of these contained PCBs on January 1, the value of small PCB capacitors in the inventory of equipment manufacturers would have been one sixtieth of annual capacitor sales of $95 million, or approximately $1.5 million on January 1, 1979. The number of PCB capacitors remaining in inventory on July 1, 1979, will probably depend on the policies of various companies regarding the maintenance of spare parts for obsolete equipment. There will apparently be sufficient time available for manufacturers to use their inventories of PCB capacitors that are components of presently manufactured products.

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*Letter from George Hakin (Emerson Quiet Kool Company) to EPA, dated August 2, 1978.

**Oral comments of Ernest Freegard (Advance Transformer Company) at the Hearings on the PCB Ban Regulation, August 23, 1978.

3.1.2 PCB Equipment

Most capacitors used in appliances and lighting fixtures manufactured during 1978 do not contain PCBs. There is no easy way to distinguish which appliances do contain PCB capacitors. The provisions of the PCB Disposal and Marking Regulations that require that non-PCB capacitors and non-PCB fluorescent light ballasts be distinguishable from PCB units did not become effective until July 1, 1978 (EPA, 1978a). The regulations that require equipment containing PCB capacitors be so marked apply only to equipment manufactured after December 31, 1978 (EPA, 1978b).

There are also considerable numbers of PCB capacitors presently in inventory in electrical subassemblies such as fluorescent light ballasts. According to Mr. Ray Clark, the manufacturers of fluorescent light fixtures normally carry a 60-day supply of ballasts in inventory, and he estimated that about one million of the seven million ballasts in their inventories on January 1, 1979, would contain PCB capacitors.* Not all of these ballasts are used within sixty days. Manufacturers of lighting fixtures also maintain inventories of the less common and obsolete ballasts for use as replacement parts in existing fixtures. Some of these ballasts may remain in inventory for as long as thirty years.** According to Mr. Freegard, the percentage of production of ballasts by Advance Transformer Company that involves the slow moving types is less than ten percent of the fluorescent light ballasts and perhaps slightly more than ten percent of the ballasts for high intensity discharge (mercury arc and sodium arc) lighting ballasts.***

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*Oral comments of N. Ray Clark (Universal Manufacturing Corporation) at the hearings on the PCB Ban Regulation, August 28, 1978.

**Oral comments of Herbert Rowe (Electronic Industries Association) at the hearings on the PCB Ban Regulation, August 23, 1978.

***Oral comments of Ernest Freegard (Advance Transformer Company) at the hearings on the PCB Ban Regulation, August 23, 1978.

Electrical equipment containing PCB capacitors may pass through several hands prior to its sale to the final consumer. For instance, air conditioning units are distributed by the manufacturer to retailers under a conditional sales agreement which allows the units to be returned to the manufacturer if they are not sold during the summer season. The unsold units are then stored during the winter and sent to retailers the following spring. Amana Refrigeration stated that "There is customarily a large amount of carry-over merchandise left over in the distribution channel after the primary selling season has ended. It is not uncommon for a dealer or distributor to have an inventory containing air conditioning equipment which is three to four years old."*

Microwave ovens do not have the seasonal sales pattern of air conditioning units, but inventory carry-over is still significant. Mr. Weizeorick of the Association of Home Appliance Manufacturers calculated the rate of sales of each year's production to be 54% per year based on a total durable goods inventory equal to 72% of annual shipments. Carry-over from the production years 1975 through 1977 would therefore be expected to be 239,000 units on December 31, 1978, and 120,000 units on June 1, 1979.** Inventories of lighting ballasts and fixtures might be expected to turn over more rapidly. However, many of these items are manufactured as components of equipment such as subway cars and highway luminaries which will be classified as PCB equipment and which have longer lead times prior to final sale to the user.

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*"Comments of Amana Refrigeration, Inc. ...." submitted to EPA as an attachment to a letter dated August 4, 1978, from Arthur Herold of Webster and Chamberlain.

**Letter from J.T. Weizeorick (Association of Home Appliance Manufacturers) to Steven Rosenthal (Covington and Burling) dated September 7, 1978 (Appendix III). This letter was submitted to the EPA as an attachment to a letter from Mr. Rosenthal dated September 12, 1978.

The manufacture of appliances using PCB capacitors is not banned until July 1, 1979, but any such appliances manufactured during 1979 must have the PCB equipment label applied. Therefore, it will be easier to identify equipment containing PCB capacitors that was manufactured during 1979 than that manufactured in 1977 and 1978.

3.2 Requirements of the Regulation

Sale of new PCB capacitors: The sale of new PCB capacitors is banned after June 30, 1979, unless EPA grants a specific exemption from this "distribution in commerce" ban requirement.

Manufacture of PCB equipment: The use of PCB capacitors in the manufacture of new equipment such as television sets, microwave ovens, and fluorescent light ballasts and fixtures is considered a totally enclosed processing of PCBs. Since all processing is banned after June 30, 1979, PCB capacitors and subassemblies containing PCB capacitors will have to be used by June 30 unless a petition for an exemption from this processing ban requirement is granted by the EPA.

Sale of new PCB equipment: The sale of new PCB equipment is banned after June 30, 1979, unless EPA grants a specific exemption from this "distribution in commerce" ban requirement.

Exemption requirements: EPA has not yet stated the conditions under which petitions for exemptions from these ban provisions will be accepted or the conditions under which exemptions will be granted except to state that any exemptions granted will be for a period of only one year. EPA has suggested that exemptions may be granted only under those conditions (1) that will result in no significant threat to health or the environment and (2) where a good faith effort to develop substitutes for the PCB capacitors has been demonstrated.

3.3 Economic Impact of the Regulation

3.3.1 PCB Capacitors

The regulation bans the distribution in commerce after July 1, 1979, of PCB capacitors unless the EPA grants exemptions from this requirement. If the EPA grants a complete exemption from this requirement, there could be zero economic impact. If the EPA does not grant any exemptions, the effect of the regulation would be to require that all small PCB capacitors be sold to the ultimate users by July 1, 1979, and that any PCB capacitors remaining in the distribution channels at that time be disposed of in accordance with the disposal requirements.

The economic impacts resulting from the ban on "distribution in commerce" will depend on the extent to which EPA grants exemptions. The number of individual small capacitors maintained in inventory as spare parts is not known but is probably no more than a few percent of one year's production of PCBs. Many of these capacitors might be relatively old, having been left over from production runs of unusual types and then kept as spares to replace units that fail in service. A rough estimate of the value of small capacitors remaining in inventory on July 1, 1979, would be that the parts inventory would equal two percent of annual production of small capacitors and that one half of these might still be PCBs. The value of small industrial capacitors was previously reported to be $94.5 million in 1976 (Versar, 1978, pp. 97-98). The manufactured cost of remaining inventories of PCB capacitors would therefore be (2% x 1/2 PCBs x $94.5 million=) $1 million. The economic loss resulting from a ban on the sale of these capacitors might be larger than this amount if equipment that is otherwise usable must be scrapped because no replacement capacitors are available. However, no information is available to support an estimate of the resulting costs.

It is anticipated that additional information will be made available to EPA in petitions for exemptions from the ban on sale of capacitors. This information will enable EPA to more accurately estimate economic impacts of their decisions on the exemption petitions.

3.3.2 PCB Equipment

Compliance with this regulation would require that all inventories of subassemblies, appliances, and lighting fixtures containing capacitors on July 1, 1979, be examined to determine whether any of the capacitors contain PCBs. Any PCB capacitors that are found will have to be replaced with non-PCB capacitors before the subassembly, appliance, or lighting fixture can be sold.

A ban on the distribution in commerce of equipment containing PCB capacitors will have a greater impact than a ban on the sale of capacitors because the equipment ban will involve more items and because it will be more difficult to identify the banned items. The major cost of the regulation would result from the efforts to identify which equipment contains the PCB capacitors so that they could be replaced with non-PCB units.

A rough estimate of the total number of items in inventory that will have to be checked to determine whether they contain PCB capacitors can be calculated from information presented by the industry. Aerovox reportedly has about 24% of the market for small industrial capacitors (Versar, 1978, p. 103) and has stated that their production rate is 80,000 units per day.* If the average unit cost of Aerovox production is representative of the industry, this would imply an annual production of (80,000 units per day x 250 days/0.24 market share=) 83.3 million capacitors per year. The average cost would therefore be ($94.5 million/83.3 million units) = $1.13 per capacitor. If dealer inventories equal 70% of annual shipments, this implies that there will be (83.3 million units per year x .7 =) 58.3 million separate pieces of equipment containing small capacitors in inventory at any given time.

The inventory model suggested by Mr. Weizeorick can be modified to calculate the fraction of units in inventory on July 1, 1979, that will contain PCB capacitors. This model assumes that production of capacitors is constant at P_o units per year, that the ratio of inventory to sales is equal to 0.71, and that the probability of sale of any given item is not proportional to the time it has been in inventory. Mr. Weizeorick stated the relationship between inventory, production, and sales by the differential equation

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*Letter from Clifford H. Tuttle (Aerovox Industries, Inc.) to EPA dated August 15, 1979.

$$\frac{di}{dt} = P-S$$

where i = inventory at time t
P = production rate, units per year
S = sales rate, units per year

and solved this equation for the condition

$t < 0,\ P = 0$
$t > 1,\ P = 0$
$0 \leq t \leq 1,\ P = P$

However, starting at about the beginning of 1977, some of the production of capacitors was of non-PCB units, and by the end of 1978, all of the capacitors being produced were non-PCB types. If it is assumed that the proportion of PCB capacitors used by equipment manufacturers decreased linearly from 100% PCB on January 1, 1977, to 0% on December 31, 1978, the production rate of equipment containing PCB capacitors during these two years could be expressed by the equation:

$$P = P_o \left(1 - \frac{t}{2}\right),\ t = 0 \text{ to } 2$$

where P_o = constant production rate using all capacitors
P = production rate using PCB capacitors
t = years after January 1, 1977.

The differential equation for the inventory of PCB items during these two years would then be expressed as

$$\frac{di}{dt} = P - S \qquad (1)$$

and since:

$$S = \frac{i}{.71} \qquad (3)$$

$$\text{and } P = P_o \left(1 - \frac{t}{2}\right), \qquad (2)$$

$$\text{then } \frac{di}{dt} = P_o \left(1 - \frac{t}{2}\right) - \frac{i}{.71} \text{ from } t = 0 \text{ to } t = 2 \qquad (4)$$

In linear form, this equation can be written:

$$di + \left[\frac{i}{.71} - P_o \left(1 - \frac{t}{2}\right)\right] dt = 0 \qquad (5)$$

which has the solution

$$i = .71\ P_o \left[1 - \frac{t}{2} + \frac{.71}{2} \left(1 - e^{-t/.71}\right)\right] \qquad (6)$$

where $i = .71\ P_o$ at $t = 0$

Evaluating for the inventory at the end of 1978 (i.e., $t = 2$), $i = .334$, or 33.4% of equipment in inventory on January 1, 1979, contained PCB capacitors.

Assuming that no PCB equipment was made after January 1, 1979, the differential equation for the inventory would be written

$$\frac{di}{dt} = -S \qquad (7)$$

Since $S = \frac{i}{.71}$, this can be written as

$$di + \frac{i}{.71} dt = 0 \qquad (8)$$

which has the solution

$$i = i_o e^{-\frac{t}{.71}} \text{ for } i = i_o \text{ at } t = 0 \qquad (9)$$

On July 1, 1979, (t = 1/2), the inventory of PCB items, will therefore be equal to .49 of the initial inventory at the beginning of the year, or equal to (.49 x .334 x P =) 16.4% of the total inventory.

Based on these calculations, the inventory of equipment containing capacitors on July 1, 1979, will consist of 58.3 million items, of which 9.56 million will contain PCB capacitors. These capacitors will have an estimated manufacturers' sales price of (9.56 million capacitors at $1.13 =) $10.85 millon. These estimates will be higher than the actual inventory of PCB capacitors to the extent that dealers succeed in selling their oldest stock first.

If the EPA does not grant exemptions from the ban on the sale of equipment containing PCB capacitors, the dealers may have to open many of the 58.3 million items to determine which items contain PCB capacitors, and then replace the capacitors in 9.56 million items with non-PCB capacitors. Major cost items for the inspection program will be labor, customer discounts required to offset the damage to the packing cartons, and supervision. In most instances, the equipment will have to be partially disassembled in order to expose the capacitor. Mr. Weizeorick suggested a cost of $40 per unit based on $20 labor, $10 administrative cost, and $10 reduced value caused by damage. This implies a total program cost of $2.33 billion to inspect all 58.3 million items. It is possible that at least some of the units could be identified as not containing PCB capacitors by checking each unit serial numbering and information supplied by the manufacturer. However, even if the labor and administrative expenses could be cut by a factor of three to an average of $10 per unit by identifying serial numbers and therefore not having to disassemble the units, the inspection program would still cost in excess of $1 billion.

The second portion of this program will consist of replacing the capacitors in the 9.56 million pieces of equipment that are found to contain PCB capacitors. Mr. Weizeorick suggested a rework cost of $75 per unit implying a total cost of $717 million. This is undoubtedly high, since many of the suspect items are fluorescent light fixtures that retail for about $10 per unit. There is not sufficient information to estimate the proportion of the 58.3 million units in inventory that would be sold at distress prices before July 1, 1979, or scrapped rather than being inspected. However, it must be concluded that the total inspection costs, rework costs, and losses due to forced sales could easily exceed $1 billion.

The calculated costs resulting from the ban on distribution in commerce of equipment containing PCB capacitors is admittedly based on a number of assumptions. However, it is anticipated that additional information on the economic impacts will be presented to the EPA by the manufacturers and distributors of this equipment together with their petitions for exemptions from these requirements.

The final cost impact of these regulations will result from the requirement that impacted manufacturers and distributors of PCB equipment apply for exemptions. These petitions will require that detailed cost estimates be prepared which in turn will require the participation of corporate marketing, accounting, and legal staff. Each petition would likely require anywhere from 3 to 30 man days of effort to prepare, and cost a total of $1,000 to $10,000 based on total burdened labor at $42 per hour. EPA has not yet announced its policy on accepting class action petitions. If each manufacturer and retailer is required to apply separately, perhaps 1,000 to 10,000 petitions will be filed, at a total cost of about $10 million.

3.4 PCBs Controlled by the Regulation

Total consumption of PCBs by the capacitor manufacturing industry during 1975 was about 21 million pounds, of which 55% was used in small industrial and appliance capacitors (Versar 1976a, p. 6). If total production of these small capacitors was 83.3 million units, the average capacitor contained (21 million x .55/83.3 million =) 0.14 pounds of PCBs.

The ban on the sales of spare capacitors would affect $1 million worth of capacitors containing a total of ($1 million x 0.14 lb PCB per unit/$1.13 per unit =) 124,000 lb PCBs. The capacitors removed from equipment in inventory would contain (9.56 million units x 0.14 lb PCB per unit =) 1,340,000 lb PCBs.

It is assumed that the spare capacitors are still owned by manufacturers of PCB equipment and will have to be disposed of in approved chemical waste landfills. The capacitors in equipment are assumed to be in dealers inventories, and these may be disposed of in municipal trash.

The failure rate of small capacitors is about 0.2% per year, of which 10% leak on failure.* If the average appliance lasts twenty years, each capacitor would have a (20 years x 0.2% probability of failure per year =) 4% probability of failure.

The effect of the regulation will be to prevent the loss of PCBs to the environment by capacitors that fail and leak in service. If it is assumed that all the PCBs in leaking capacitors enter the environment, the effect of the regulation would be to reduce the loss of PCBs from equipment by (1,340,000 pounds PCBs x 4% fail x 10% leak =) 5,360 pounds of PCBs. The rest of the PCBs in capacitors installed in equipment will end up in municipal landfills whether they are removed in 1979 or when the equipment fails.

All of the spare capacitors will have to be disposed of in chemical waste landfills, thereby preventing the entry into the environment of (124,000 pounds x 4% fail x 10% leak =) 496 pounds PCBs that would have occurred had these capacitors been used.

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*Letter from George Hakin (Emerson Quiet Kool Co.) to EPA dated September 6, 1978.

Municipal landfills are not as safe a repository for PCBs as are approved chemical waste landfills. However, PCBs are rather immobile in material with high organic content and would not be expected to leach out of municipal waste if present in low concentrations. No information is available on which any estimate can be made as to the fraction of the PCBs from intact capacitors that are expected to leach from municipal landfills.

3.5 Summary - Economic Impacts

Inventory losses:	Spare capacitors	$1 million
	This cost will be reduced significantly or eliminatead if EPA grants exemptions from the "distribution in commerce" ban.	
Inspection and rework:	PCB Equipment	$1 billion
	This cost will be reduced significantly or eliminated if EPA grants exemptions from the 'distribution in commerce" ban.	
Petition costs:		$10 million*

3.6 Cost Per Pound of PCBs Kept From the Environment

Spare capacitors:

$$\frac{\$1 \text{ million}}{500 \text{ pounds}} = \$2{,}000 \text{ per pound PCB}$$

This cost will be reduced significantly or eliminated if EPA grants exemptions from the "distribution in commerce" ban.

Capacitors in equipment:

$$\frac{\$1 \text{ billion}}{5360 \text{ pounds}} = \$187{,}000 \text{ per pound PCB}$$

This cost will be reduced significantly or eliminated if EPA grants exemptions from the "distribution in commerce" ban.

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*May be significantly reduced if EPA accepts class action petitions for exemptions to the ban on "distribution in commerce."

4.0 IMPACTS ON USERS OF ASKAREL TRANSFORMERS

4.1 Present Status

In calculating the economic impact of the PCB Disposal and Marking Regulations, Versar estimated that there are about 140,000 transformers presently in service that were manufactured as PCB (askarel) transformers (Versar, 1977). These transformers were originally filled with a coolant liquid that contained from 60% to 100% PCBs. Although over 100 of these transformers have been retrofilled with silicone or hydrocarbon coolant liquids, none of them have been sufficiently decontaminated so that the concentration of residual PCBs is below 500 ppm.*

Approximately 1000 of the askarel transformers are installed on railway locomotives and commuter cars (Versar 1978, p. 19). These units are addressed specifically by the PCB ban regulations, and the impact of the regulations on these units is discussed in Chapter 5. Of the remaining units, most are pad mounted distribution and power transformers located in buildings and in electric generating stations, with a substantial number of askarel precipitator transformers being mounted on stacks. It is estimated that askarel transformers each contain an average of 2,500 pounds of PCB. The distribution of ownership of these askarel transformers was previously estimated to be as described in Table 4.1-1. No additional information on the ownership of askarel transformers was presented in the written or oral comments submitted to EPA after the PCB Ban Regulations were proposed.

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*Enclosure with letter from Terry Michaud (Dow Corning Corp.) to EPA dated August 1, 1978.

Table 4.1-1*

Estimated Number of PCB Transformers in Service

Category of User	Number of Units	PCB Content-Pounds
Utilities	42,000	105,000,000
Industrial and Commercial	97,000	191,000,000
Railroad	1,000	4,000,000

*Source: Versar, 1978, p. 19.

The PCB Ban Regulations define askarel transformers as being any transformers that are filled with a liquid containing PCBs in concentrations exceeding 500 ppm. This chapter discusses the impact of the regulation on transformers that were originally filled with a PCB based dielectric fluid. Chapter 6 discusses the impact of the regulation on those transformers that were originally filled with mineral oil but which have since become contaminated with PCBs in concentrations above 500 ppm.

4.2 Requirements of the Regulation

Rebuilding and major maintenance: The regulations forbid the removal of the core and coils from the transformer. As a result, any significant electrical problem involving the windings of an askarel transformer will result in the unit being scrapped. However, retrofilling a PCB transformer several times with a non-PCB liquid may reduce the residual concentration of PCBs to below 500 ppm. The ban on rebuilding does not apply to such decontaminated transformers.

Minor maintenance: There are no restrictions on the performance of maintenance that do not require removal of the coils. After July 1, 1979, transformer service companies cannot sell used or reclaimed askarel unless they have petitioned for an exemption from the provisions of the regulation which ban the processing of PCBs prior to their distribution in commerce.

Reclaiming PCB askarel: After June 30, 1979, PCBs may be reclaimed for reuse only by those who have petitioned the EPA and been granted an exemption from the "processing" bans.

Storage of PCB askarel: Storage prior to use or resale must be in a specially marked area which meets the requirements established by the disposal regulations.

Disposal of failed transformers and PCB based askarel: No change from the previously promulgated Disposal and Marking Regulations.

Retrofill with non-PCB fluid: Authorized without restriction. The retrofilled transformer must continue to be considered a PCB transformer, until the liquid has been tested at least three months after the transformer was returned to service and found to contain less than 500 ppm PCBs. The transformer is then classified as a PCB contaminated transformer.

4.3 Economic Impact of the Regulation

Foregone savings from rebuilding

Askarel transformers have a normal service life of 30 to 40 years or more (Versar 1978, p. 7). Premature failure can occur as the result of electrical breakdown of the insulation or distortion of the coils caused by severe overload conditions. Normal industrial practice has been to rebuild failed askarel transformers by removing the core and coils, burning off the coils, and rewinding the coils using new wire on the original core. This repair normally costs about 60% of the price of a new transformer, and the repairs take about 25% as long as normal delivery of a new unit.* This rebuilding service is offered by both the original manufacturers of the transformers and by approximately 300 small transformer service companies.**

Based on an average price of $20,000 per new transformer (Versar 1978, p. 20), the ban on rebuilding askarel transformers will result in foregone savings of ($20,000 x (1-60%) =) $8,000 per transformer. In addition, the ban will increase the time required to restore service from the present one to two months to six months or more, depending on the availabilty of a satisfactory new transformer*. The out-of-service time might even be longer than would be expected based on past practices because the ban on the manufacture of new askarel transformers will require that each installation of existing askarel transformers be redesigned when the transformer fails and must be replaced. Adequate replacement transformers are usually available in a number of designs including oil-filled transformers with protective vaults and sprinklers, high fire point liquid-filled transformers, and various types of dry transformers. However, none of these designs are direct replacements for existing askarel transformers, so a certain amount of engineering time must be added to the normal delivery time for a new unit.

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*Oral comments of Mr. Lynwood Holley (American Electric Apparatus Repair Corporation) at the hearings on the PCB Ban Regulations, August 28, 1978.

**Oral comments of Robert Sandman (Sandman Electric Company) at the hearings on the PCB Ban Regulations, August 28, 1978.

An active market in used askarel transformers existed in the past, but that market has declined over the past year due to uncertainties about the restrictions that EPA was expected to impose on the use of these units. The PCB ban regulations do not affect the resale and reuse of askarel transformers by users, and units removed from service because of changes in service demands might be made available as replacement units for some of the failed askarel transformers. However, the risk of a spill occuring during transport of an askarel transformer and the high potential liability incurred by any spill of PCBs will probably limit any market in used askarel transformers.

Not enough information is available to estimate the proportion of askarel transformers that would have been scrapped due to obsolescence rather than due to electrical failure; most existing askarel transformers have not been in service long enough for either aging or changing service demands to be significant. Assuming as an example that from one third to two thirds of the existing askarel transformers would have been rebuilt if it were not for the ban on rebuilding, the total foregone savings would be $8,000 per unit x 1/3 to 2/3 of the 140,000 units in service (Versar, 1978, pg. 21), or a total of $373 million to $747 million over the next 40 years.

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*Letter from Robert L. Sandman (Electrical Apparatus Service Association, Inc.) to EPA (PCB Ban Regulation Hearing Record), Undated.

These foregone savings will not be distributed evenly over the next 40 years because present failure rates of askarel transformers are relatively low. The failure rate is likely to increase as the average age of the transformers increases. It was previously estimated that approximately 80,000 gallons of PCBs were used in the repair of askarel transformers in 1974 (Versar, 1976a). This is enough PCB to fill 335 transformers with an average capacity of 240 gallons of liquid (Versar 1978, p. 21). Many transformer service companies have also used reclaimed askarel in rebuilt transformers, so the actual number of transformers rebuilt may be three to four times the number calculated from data on the use of new askarel (approximately 1200 per year). The amount of business lost to the transformer rebuilding industry due to the ban on the rebuilding of askarel transformers might be as much as (1200 transformers per year x $12,000 per unit =) $14.4 million per year. The transformer manufacturers would supply new units to replace those not rebuilt at an average cost of $20,000, so increased costs due to the regulation may be about (1200 units x $8,000 =) $9.6 million per year. Increased labor requirements by the manufacturers are expected to offset any job losses by the repair shops, and in fact little unemployment is expected in the transformer service industry because nearly all of the 300 companies that service askarel transformers also service oil-filled transformers. Since about 97% of large, pad mounted, liquid-filled transformers contain mineral oil, the ban on the rebuilding of askarel transformers should have a relatively small impact on the level of transformer repair business.

Lost service time

The delay in replacing failed askarel transformers might increase in some cases from the present four weeks required to rebuild a unit to as much as six months (Versar 1978, p. 21). This delay could have serious economic impacts on any industrial plant that was dependent on a single transformer for its power. Rental units might be available, but at a higher cost to the plant. The previous estimate of increased rental costs for temporary replacement transformers was $2,380,000 per year starting in 1979 (Versar, 1978). No additional data were submitted to the EPA in written or oral comments on the proposed regulation that would support any revision of this estimate.

Limitations on sale of reclaimed askarel

The regulations do not impose any restrictions on the processing of PCB based askarel by the owner of a transformer or by a service company that returns the askarel to transformers having the same owner. Therefore, there will be no restrictions on the present maintenance practice of periodically filtering the askarel in operating transformers to reduce the moisture content and improve its electrical properties. However, after June 30, 1979, sale of PCBs will be allowed only if the owner has petitioned the EPA for and been granted an exemption from the ban on the distribution in commerce of PCBs. If the EPA does not grant exemptions, there will be a lack of available PCBs to top off askarel transformers that may develop small leaks and to replace the PCBs absorbed by the filtering material when askarel is routinely filtered. However, since it is technically feasible to dilute askarel with various solvents, including trichlorobenzene, RTEmp®, and Iralec®, without damaging its electrical properties, there may be little economic impact caused by the ban on sale of new and reclaimed PCBs. It should be noted that PCBs from PCB tranformers that have been disposed of or are designated for disposal must be incinerated and therefore are not available for recycle or reuse.

Disposal of failed transformers and askarel liquids

The PCB Ban Regulations do not change the requirements previously imposed by the PCB Disposal and Marking Regulations in this area (EPA, 1978a), and therefore there are no additional economic impacts.

Retrofill with non-PCB fluid

The PCB Ban Regulations clarify the conditions under which a retrofilled transformer may be considered to be in the same class as oil-filled transformers for purposes of servicing and disposal. However, the regulations do not establish any limitations on retrofilling. Therefore, the effect of the regulations may be to reduce servicing problems when make-up askarel is no longer available and to reduce eventual disposal costs in some cases.

Ban on sale of PCBs

Effective July 1, 1979, neither unused PCBs nor reclaimed PCB based askarel will be allowed to be sold unless the seller has petitioned for and been granted an exemption by the EPA from the "distribution in commerce" ban. If the EPA does not grant exemptions, there will be a lack of available PCBs to replace askarels lost through small leaks or to replace the PCBs absorbed by the filtering material when askarel is routinely filtered. However, since it is technically feasible to dilute askarel with various solvents, including trichlorobenzene, RTEmp®, and Iralec®, without damaging its electrical properties*, there may be little economic impact caused by the ban on the sale of new and reclaimed PCBs.

Ban on processing PCBs for sale

The Toxic Substances Control Act defines the processing of a chemical as "the preparation of a chemical substance or mixture, after its manufacture, for distribution in commerce..." (Section 3(10)). Therefore, activities with PCBs that do not involve its sale are not considered to be "processing" as defined by the Act, and such activities performed for the purposes of maintaining transformers in other than a "totally enclosed manner" are specifically authorized by the regulation until July 1, 1984. This means that there are no restrictions on the filtering or other handling of askarel unless there is a change in the ownership of PCBs. Transformer askarel can continue to be tested and maintained by either the owner of the transformer or by a service company, but no PCBs can be added to the transformer except those that were owned by the owner of the transformer no later than 30 days after the effective date of the regulation. In addition, "processing" and "distribution in commerce" for purposes of disposal are specifically authorized by the regulation.

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*Olmsted, J. (1977) "Comments and Recommendations on Makeup Fluid for Askarel Transformers", Waukesha, WI.: RTE Corporation, November 15, 1977. (Submitted to the PCB Regulation Hearing Record as an attachment to RTE Corporation "Main Comments").

The only significant impact of this provision will be to ban the salvaging of used PCBs by transformer service companies for use in maintenance of other transformers. However, the major use of such reclaimed askarels has been in rebuilt transformers, and the rebuilding of askarel transformers is being specifically banned. The economic impacts of the ban on "processing" PCB based askarels have been included in the estimated cost of the ban on rebuilding askarel transformers.

Disposal of failed transformers and askarel liquids

The PCB Ban Regulations do not change the requirements previously imposed by the PCB Disposal and Marking Regulations in this area (EPA, 1978a), and therefore there are no additional economic impacts.

Retrofill with non-PCB fluid

The PCB Ban Regulations clarify the conditions under which a retrofilled transformer may be considered to be in the same class as oil-filled transformers for purposes of servicing and disposal. The regulations do not establish any limitations on retrofilling. The effect of retrofilling may be to reduce servicing problems when make-up askarel is no longer available and to reduce eventual disposal costs in some cases. The ban regulations impose no economic costs relative to retrofilling of askarel transformers.

4.4 PCBs Controlled by the Regulation

The ban on rebuilding askarel transformers will eliminate the loss of PCBs to the atmosphere that occurs when a transformer is baked-out prior to removal of the coils. There is no information available on the PCB losses that occur during this process. However, if total losses of PCBs during rebuilding of an askarel transformer were controlled to one to ten pounds per unit, the regulation would reduce the entry of PCBs into the environment by (1 to 10 lbs per unit x 1/3 to 2/3 of 139,000 units =) 47,000 to 925,000 lbs.

The ban on the sale of PCBs should accelerate the retirement of askarel transformers, but there is not sufficient information available to estimate the effect this will have on the amount of PCBs entering the environment.

4.5 Summary - Economic Impacts

Foregone savings from rebuilding:	\$9.6 million (1979); \$373 million to \$747 million total
Lost service time (increased rental of replacement transformers):	\$2.38 million per year

4.6 Cost Per Pound of PCBs Kept from the Environment

Ban on rebuilding

$$\frac{\$373\text{ million to }\$747\text{ million} + 23.8\text{ million}^{*}}{47{,}000\text{ to }925{,}000\text{ lb}} = \$429\text{ to }\$16{,}400\text{ per pound PCB.}$$

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*Present value of one dollar per year indefinitely discounted at 10% equals \$10.

5.0 RAILROAD LOCOMOTIVE TRANSFORMERS

5.1 Present Ownership and Use Plans

Many of the major railroads in the northeastern United States are electrified. High voltage alternating current is supplied at 25 hz, 11,000 volts, by overhead catenaries to electric locomotives and multiple unit electric commuter cars (MUEC). Transformers on board the locomotives and MUEC cars reduce the voltage to the level required by the traction motors. These transformers are specially designed to fit into the limited space available on the car or locomotive and are built to withstand severe shock and vibration. The transformers incorporate a pump to force the coolant liquid through cooling fins and thereby improve the thermal efficiency of the units. It has been standard practice to use PCB based askarel coolant liquids in these transformers because of the possibility of a severe fire should a derailment occur in one of the tunnels leading into New York City.

The federally funded Northeast Corridor Improvement Project is upgrading much of the power distribution system between Washington, D.C. and New York City. According to Mr. Clifford Gannett of the Federal Railroad Administration, the scheduled completion date for conversion of the power on this portion of the railroad system is now September, 1983*. The conversion of the catenary power to 60 hz, 25,000 volts, will have a major effect on the continued use of many of the present askarel transformers on locomotives and MUEC cars operating in this area. Although some of the newer equipment can be converted to operate at the higher voltages by changing internal taps in the transformers, many of the transformers will have to be replaced, and the railroads intend to scrap many of the oldest cars and locomotives rather than to invest in the new transformers that would be required to keep them operating. Table 5.1-1 lists the ownership of the MUEC cars and locomotives using PCB cooled transformers that are presently in service and summarizes the effect of the voltage conversion on the continued use of these transformers.

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*Original information indicated 3rd quarter of 1982. Letter from Clifford Gannett (Federal Railroad Administration) to EPA dated September 18, 1978. Subsequent press reports indicated completion in September of 1983. This was confirmed by a telephone call to Mr. Gannett in February 1979 (See telephone memo dated February, 1979 from Harold Snyder, OTS/EPA to record.)

5.2 Requirements of the PCB Ban Regulations

Use of PCB railroad transformers: Authorized until July 1, 1984 subject to the following limits on the concentration of PCBs in the dielectric liquid:

After January 1, 1982: 6% PCBs maximum
After January 1, 1984: 0.1% PCBs maximum

Servicing and retrofilling of PCB railroad transformers and treatment of PCBs in other than a totally enclosed manner: Authorized until July 1, 1984, provided that there is no change in the ownership of any PCBs.

Processing of PCB contaminated liquid prior to sale for servicing transformers: Banned after July 1, 1979, unless EPA grants an exemption from the "processing" ban regulation.

Sale of PCBs for servicing railroad transformers: Banned after July 1, 1979, unless EPA grants an exemption from the "distribution in commerce" ban regulation.

Testing of liquid in PCB railroad transformers to determine concentration of PCBs: Required immediately after any servicing that is performed to reduce the concentration of PCBs and again 12 to 24 months later. Records of these analyses must be maintained until January 1, 1991.

Rebuilding PCB railroad transformers in other than a totally enclosed manner: authorized until July 1, 1984. However, any transformer rebuilt after January 1, 1982, must be refilled with liquid containing less than 50 ppm PCBs.

Table 5.1-1

Summary of PCB Cooled Railroad Transformers in Service (One Transformer per Car)

Owner	Type of Equipment	Number of PCB Transformers	Effect of Late 1982 Voltage Change Number Cars Scrapped	Effect of Late 1982 Voltage Change Number Transformers Replaced	Effect of Late 1982 Voltage Change Number PCB Transformers to Remain in Service	Gal/Trans.
SEPTA	MUEC	344	38	74	232	
NJDOT	MUEC	122	18	0	104	
Conn DOT/MTA	MUEC	244	0	0	244	
MD DOT	MUEC	7	7	0	0	
Conrail	GG 1 Loco.	51	51	0	0	710
Conrail	E33, E44 Loco.	76	0	76	0	500
Amtrak	Metroliner	61	0	2	59	255
Amtrak	GG 1 Loco.	33	33	0	0	710
Amtrak	E60 Loco.	26	0	0	26	380
		964	147	152	665	

All data from letter to EPA from Mr. Clifford Gannett, Federal Railroad Administration, 9/15/78.

Maximum concentration of PCBs in liquid used to service or top off railroad transformers:

No restriction until January 1, 1982. 6% PCBs from January 1, 1982, until January 1, 1984. 0.1% PCBs after January 1, 1984.

5.3 Cost Impacts of the PCB Ban Regulations

July 1, 1984 deadline on continued use of PCB railroad transformers:

It has not been demonstrated that it is technically possible to reduce the concentration of PCBs in PCB railroad transformers to below the 500 ppm level that is used to distinguish "PCB transformers" from "PCB contaminated transformers." It is anticipated that EPA will review the technology of retrofilling and processing of transformer liquids before the July 1, 1984, ban on the use of railroad transformers containing more than 500 ppm PCBs to assure that this requirement does not cause substantial economic impacts. Compliance with these regulations will therefore require that the affected railroads maintain close communication with EPA to resolve any unanticipated problems. There is not sufficient information in the record to support any estimate of the costs that will be incurred by the railroads in participating in the eventual review of these regulations.

Required reduction of PCB levels to below 6% by January 1, 1982:

It has been demonstrated that a single retrofilling procedure consisting of draining, flushing, and refilling with non-PCB coolant liquid can result in PCB concentrations substantially below 6% (Walsh, 1977;* Foss, 1977**). The analysis of the impacts of the proposed PCB regulation assumed a total materials and labor cost of $20 per gallon for retrofilling a transformer a single time with silicone liquid (Versar, 1978). A revised estimate for the cost of retrofilling a transformer based on the procedure developed by Dow Corning Corporation (Page, 1977)* is summarized in Table 5.3-1. The use of silicone at $12 per gallon (Versar, 1978, p. 30) in estimating retrofill costs should give an upperbound but reasonable figure because, although the alternative liquids may be cheaper, only silicone can be treated to remove dissolved PCBs by filtration.

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*Walsh, E.J., D.E. Voytik and H.A. Pearce, (Westinghouse Electric Corp.) 1977. Evaluation of Silicone Fluid for Replacement of PCB Coolants in Railway Industry, Final Report. Report No. DOT-TSC-1294. Cambridge, Ma.: Transportation Systems Center, U.S. DOT. December 1977 (attachment to reply comments from Clifford Gannett (Federal Railroad Administration)).

**Foss, Stephen D., John B. Higgins, Donald L. Johnston, and James M. McQuade (General Electric Co.). 1977. Retrofilling of Railroad Transformers. Cambridge, Ma.: Transportation Systems Center, U.S. DOT, July 1978 (attachment to reply comments from Clifford Gannett (Federal Railroad Administration)).

The total cost of retrofilling the 964 existing PCB railroad transformers is calculated in Table 5.3-2 to be $6.6 million. Many of these transformers will be scrapped in late 1982 when the scheduled voltage change on the Northeast Corridor is made. It is therefore possible that at least some of the transformers will be replaced prior to January 1, 1982, with units which can operate at both the present voltage and the higher voltage that is planned. If this replacement is made prior to the date specified for the 6% PCB limit, the present transformers will not have to be retrofilled. The cost of this retrofill requirement can be calculated by assuming that all of the transformer replacements are made by January 1, 1982, and that retrofilling is only performed on the 665 transformers that will remain in service under higher voltage conditions. The cost of this limited retrofill program is calculated to be $3.7 million. If the changeover does not occur until September, 1983, all of the cars will have to be converted to non-PCB transformers in order to take advantage of the remaining useful life of the exisitng equipment.

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*Page, William C. and Terry Michaud (Dow Corning Corporation). 1977. "Development of Methods to Retrofill Transformers with Silicone Transformer Liquid," IEEE Paper 22-477 presented at the Electrical Insulation Conference, Chicago, Illinois, September, 1977 (attachment to letter from Terry Michaud to EPA dated August 1, 1978).

Table 5.3-1

Retrofill of PCB Railroad Transformer with Silicone - 300 Gallon Capacity Assumed

		Cost	
Step	Procedure	Materials	Estimated Labor-man hours
1	Hot drain askarel from transformer (85% removal - Foss, 1977)	5 drums @ $25.00* = $125.00	2 hours
2	Fill with 255 gallons trichlorobenzene, circulate and drain	255 gal TCB @ $5.21 = $1329.00	4 hours
3	Fill with silicone	300 gal silicone @ $12.00 = $3600.00	2 hours
4	Dispose of liquid (Rollins, 1978)***	10 drums @ ($115/drum disposal + $27.28 transportation @ $0.04/lb = $1423.00	--
	Sub-total:	$6477.00	8 hours @ $15.00**
	+ Labor Cost: @ $15. per hour	$120.00	
Total cost per transformer:		$6477.00	
	Cost per gallon:	$21.99	

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*Versar 1977, pp. 3-8.

**Versar 1978, p. 33.

***Rollins Environmental Service, Inc. 1978. Indemnified Disposal Service for Polychlorinated Biphenyls (PCBs - Askarels), May 1, 1978. Submitted as an attachment to letter from James Thompson (T&R Electric Supply Co.) to EPA, dated August 28, 1978.

Table 5.3-2

Cost of Retrofilling Railroad Transformers to Meet
January 1, 1982 Limit of 6% PCBs: $21.99/gal.

	Assume All Transformers Retrofilled				Assume Transformer Replacement Program Finished by January 1, 1982	
Owner	Equipment	Gallons/ Transformer*	Number of Transformers	Cost	Number of Transformers	Cost
SEPTA	MUEC	250	344	$1,891,000	232	$1,275,000
NJDOT	MUEC	250	122	671,000	104	572,000
CONN DOT/MTA	MUEC	250	244	1,341,000	244	1,341,000
MD DOT	MUEC	250	7	38,000	0	0
CONVAIL	GG1 Loco	710	51	796,000	0	0
CONVAIL	E33, E44 Loco	500	76	836,000	0	0
AMTRAK	Metroliner	255	61	342,000	59	331,000
AMTRAK	GG1 Loco	710	33	515,000	0	0
AMTRAK	E60 Loco	380	26	217,000	26	217,000
			Total:	$6,647,000		$3,736,000
				(302,000 gallons)		(170,000 gallons)

*Versar, 1978, p. 28.

Required reduction of PCB levels to below 0.1% by January 1, 1984.

Reduction of the concentration of PCBs in each of 665 retrofilled transformers from an assumed average concentration of 5% to 1,000 ppm will require two separate retrofilling procedures, assuming that each retrofill reduces the amount of PCBs in the transformer by at least 86%. It was suggested that silicone liquid could be processed essentially in place to reduce the concentration of PCBs and that this processing would cost $4,600 per transformer + $25 per gallon of liquid in the transformer, or an average of $40.33 per gallon for a 300 gallon capacity transformer.* This estimate was based on an assumed loss of ten pounds of silicone per gallon of liquid treated by activated carbon, or a recovery efficiency of -25% (i.e., 10 pounds of new silicone would be lost in processing and recovering 8 pounds of contaminated silicone). This analysis indicates that it would be cheaper to use new silicone at $12 per gallon, even though activated carbon has been shown to remove PCBs from silicone.** The cost of each retrofill would be $15.14 per gallon as calculated in Table 5.3-3. Total cost to the railroads for the two retrofill procedures required to reduce the PCB concentration in each transformer to below 1000 ppm would then be (170,000 gallons x 2 retrofills x $15.14 per gallon =) about $5.15 million. This cost could be reduced if a less expensive disposal method became available or if some way were developed to reclaim the silicone.

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*Attachment 2 to "Comments on Proposed Regulations to Ban PCBs." Submitted by General Electric Co. as a written comment to the EPA Hearing Record on the PCB Ban Regulations. Undated.

**Dow Corning Corporation. Removal of PCB from Dow Corning 561® Transformer Liquid by Charcoal Filtration, Midland, Michigan: Undated (As cited in Versar, 1978, p. 29).

Table 5.3-3

Retrofill of Contaminated Silicone Filled Transformer - 300 Gallon Capacity Assumed

		Cost	
Step	Procedure	Materials	Labor-man hours
1	Hot drain silicone (85% removal of liquid)		2 hours
2	Flush with 45 gallons silicone, (additional 3% removal of PCBs)	$540.	2 hours
3	Refill with 255 gal. new silicone ($12/gallon)	$3060.	2 hours
4	Disposal of 6 drums contaminated silicone (@$142)	$ 852.	
	Sub-total:	$4452.	6 hours
	Plus Labor Cost @ $15/hour:	$90.	
	Total cost per transformer:	$4542.	
	Average cost per gallon:	$15.14	

It should be noted that the highest calculated total cost of the retrofill program of \$21.82/gallon (Table 5.3-1) + 2 x \$15.14/gallon (Table 5.3-3) = \$52.10/gal is somewhat less than the estimated cost of \$78 per gallon assumed by Charles Engelhardt of Amtrak and by Dean Aboudera of the American Public Transit Association in their oral comments at the August 31, 1978, hearings on the proposed PCB Ban Regulation. However, it is felt that the estimate of \$52.10 per gallon is in fact an upper bound estimate of the cost impact of the PCB Ban Regulation because of the opportunities available for cost reduction by use of other materials being evaluated by the Federal Railroad Administration such as RTEmp® and Iralec T-1®.*

Testing to determine concentration of PCBs in liquid.

Testing of the liquid in each railroad transformer that remains in service will apparently be required four times: upon completion of each of the three retrofill procedures and again 12 to 24 months after the completion of the final retrofill. Only the initial testing will be required for those transformers that are replaced in late 1982. There has been no information submitted to the EPA on the recommended methodology or estimated cost of analyzing samples of silicone oil for the presence of PCBs. The methodology for this analysis should be about the same as for PCBs in mineral oil, although the silicones would require additional maintenance of the column in the gas chromatograph. Cost of each analysis therefore might be \$125 to \$150, including order processing costs. Total cost of the required analyses would be expected to be \$440,000 as calculated in Table 5.3-4.

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*Oral comments by Clifford Gannett (Federal Railroad Administration) at August 31, 1978 hearing.

Table 5.3-4

Cost of Analyzing Silicone Oil for the Presence of PCBs in Retrofilled Railroad Transformers

Initial retrofill: 964 Samples @ $150	=	$144,600
3 x 665 transformers @ $150	=	$299,250
Total analytical cost	=	$443,850.

5.4 PCBs Controlled by the Regulation

There are presently about 4,000,000 pounds of PCBs in use in railroad transformers. The final disposal of this material was regulated by the PCB Marking and Disposal Regulations. The effect of the present regulations is to reduce the amount of PCBs lost by leakage of transformers by requiring that the PCBs be removed from the transformers and be replaced with other liquids. Although it was noted that railroad transformers often lose liquid by leaks and venting, no information was presented to the record that would support a quantitative estimate of the PCBs required to top off these transformers to replace lost liquid. Therefore, no estimate can be made of the effect of the required retrofill program on the entry of PCBs into the environment.

5.5 Summary - Economic Impacts

Cost of reducing PCBs to 6%	$6.6 million (silicone in 964 transformers).
Cost of reducing PCBs to 1000 ppm	$5.15 million (silicone in 665 transformers).
Analytical Costs:	$444,000

5.6 Cost Per Pound of PCBs Kept from the Environment

At best, each retrofill prevents the entry into the environment of the amount of PCBs removed from the transformers.

Reduce PCBs to 6%:

$$\frac{\$6.6 \text{ million} + \$140{,}000}{.94 \times 4 \text{ million pounds}} = \$1.75^{*} \text{ per pound PCB}$$

Reduce PCBs to .1%:

$$\frac{\$5.15 \text{ million} + \$300{,}000}{170{,}000 \text{ gallons} \times 8 \text{ lb/gal} \times 5.9\% \text{ PCBs}} = \$68^{*} \text{ per pound PCB}$$

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*Assumes all PCBs would be lost to the environment if not removed by retrofilling.

6.0 OIL-FILLED POWER AND DISTRIBUTION TRANSFORMERS

6.1 Present Contamination of Oil Filled Transformers

The PCB ban regulations lower the level at which PCB contaminated mineral oil is regulated from 500 ppm to 50 ppm. A mineral oil transformer may fall into one of three categories. A mineral oil transformer that has been tested and found to contain over 500 ppm PCBs is classified as a "PCB Transformer." A transformer that has not been tested or that has been tested and found to contain between 50 ppm and 500 ppm PCBs is a "PCB-Contaminated Transformer." Transformers that have been tested and found to contain less than 50 ppm PCBs are not subject to regulation.

Most liquid-filled transformers have been filled with transformer oil, a non-chlorinated petroleum product similar to SAE 10 motor oil (Versar, 1976a, p. 255). These transformers are similar in design to PCB askarel transformers, and many of the oil-filled transformers were built in the same plants that manufactured askarel transformers (Versar, 1976a, p. 84). The total number of oil-filled transformers presently in service was previously estimated to be about 30,000,000 overhead and distribution transformers (each containing an average of 16 gallons of oil) and 5,000,000 other distribution and power transformers (each containing an average of 250 gallons of oil) (Versar, 1978, pp.36-39). It was also estimated that nearly all of the pole mounted transformers and perhaps 80% of the other oil-filled transformers are owned by electric utilities (Versar, 1978, pp. 39-40).

During the hearings on the proposed regulation, a number of utilities and transformer repair companies presented information on the results of sampling programs that they conducted to evaluate the extent of PCB contamination of oil-filled transformers. This information is summarized in Tables 6.1-1 and 6.1-2. The reply comment from the Edison

Table 6.1-1

Utility Reports of PCB Contamination of Oil Filled Transformers with Concentrations Above 50 ppm

Company	Reference Note Number	Pole Mounted Distribution Transformers	Other Transformers	Other Samples	Sampling Procedure
Allegheny Power Service Corp.	1	0 of 2	9 of 33* 0 of 2	oil storage tanks: 0 of 2	* 33 randomly selected substation transformers. Other 6 samples were not part of the random sample.
Boston Edison	2	--	--	1 oil storage tank: PCBs <5 ppm	
Commonwealth Edison	3	0 of 9	4 of 12		100 selected to be representative of age of operating transformers; no data on how these 21 samples were chosen to be analyzed first, (210 ppm max).
Consumers Power	4	--	4 of 29	55 gallon drums of oil: 0 of 4	Many samples were submitted from a repair shop. Others are samples taken from transformers in various parts of the state.

Table 6.1-1 (Continued)

Company	Reference Note Number	Pole Mounted Distribution Transformers	Other Transformers	Other Samples	Sampling Procedure
Dayton Power and Light	5	—	5 of 17 (in service) 0 of 9 (new)		Some of the 17 used transformers were selected because it was known that PCBs were used in the plants where they were manufactured.
Detroit Edison	6	—	2 of 4 *	Reclaimed oil storage tanks: 0 of 3	* maximum = 80 ppm.
Duke Power Co.	7	—	51 of 161 *		Only transformers rated at less than 44 kv; higher voltage units thought to be less contaminated. * of 161 sampled, 3 were above 500 ppm, 7 between 100 and 500 ppm, 41 present below 100 ppm but not quantified. "....it was assumed that all samples with detectable amounts of PCBs were contaminated above the 50 ppm level."

Table 6.1-1 (Continued)

Company	Reference Note Number	Pole Mounted Distribution Transformers	Other Transformers	Other Samples	Sampling Procedure
GPU Service Corporation	8	15 of 58 distribution transformers	--	oil storage tanks: 2 of 18	4 in range 100-499 ppm, 2 above 500 ppm.
GPU Service Corporation	9	--	25% of oil in 144 substation transformers		
Northern States Power Co.	10	(0 of	6)		Transformers at repair shop.
Ottertail Power Company	11	--	0 of 1	oil storage tank: 0 of 1 (31.4 ppm)	
TVA	12	--	2 of 38	--	Planned random sample.

Table 6.1-1 Notes

1/ Letters from Nancy H. Gormley (Allegheny Power Service Corp.) to EPA dated August 4, 1978 and September 7, 1978.

2/ Letter from Charles Dolloff (Boston Edison Co.) to EPA dated July 5, 1978.

3/ Letter from John Hughes (Commonwealth Edison) to EPA dated August 4, 1978.

4/ Letter from Nathan Haskell (Consumers Power Co.) to EPA dated August 7, 1978.

5/ "Supplemental Comments" submitted to EPA by Harold F. Fox (Dayton Power and Light Company), August 18, 1978.

6/ Letter from Skiles Boyd (Detroit Edison) to EPA dated August 3, 1978.

7/ Written Comments - "Response Concerning EPA's Proposed PCB... Bans..." - submitted by Duke Power Co., August 4, 1978 and oral comments by Mr. N. J. Melton (Duke Power Co.) at the PCB Hearings, August 21, 1978.

8/ Letter from J.R. Thorpe (GPU Service Corp., a subsidiary of General Public Utilities) to EPA dated August 4, 1978.

9/ Letter from Edmund Newton, Jr. (GPU Service Corporation) to EPA dated October 6, 1978.

10/ Oral Comments of Lyle Salmela (Northern States Power Company/Mid-Continent Area Power Pool) at PCB Hearings, August 22, 1978, (pp. 78-79 of transcript).

11/ "Comments of Ottertail Power Co. on the Proposed Amendments to 40 CFR 761." Undated.

12/ Letter from William Gerstner and Paul Greiner (Edison Electric Institute) to EPA dated August 7, 1978; Exhibit III.

Table 6.1-2

Transformer Manufacturer and Service Company Reports of PCB Contamination of Oil Filled Transformers Above 50ppm.

Company	Reference Note Number	Pole Mounted Distribution Transformers	Other Transformers	Other Samples	Sampling Procedure
General Electric	1	4 of 75	8 of 164		Samples analyzed at Customer request. Note: These two groups of data from GE may overlap.
General Electric	2	(25 of	55)		
RTE	3	(0 of	19)		
T&R Electric Supply	4	6 of 14		2 oil storage tanks: 72ppm and 82ppm	Random sample of used pole mounted transformer in inventory. Average 103ppm PCBs.
Transformer Consultants	5	(185 of	434)		On customer request - primarily industrial clients; 72 of the transformers had more than 500ppm PCBs, although several of these may have been retrofilled askarel transformers.

Table 6.1-2 Notes

1. Letter from William Gerstner and Paul Greiner (Edison Electric Institute) to EPA dated August 7, 1978. Exhibit III.
2. Versar. 1978, p. 40. Confirmed in letter from James Young (General Electric) to EPA dated October 6, 1978.
3. "Main Comments ..." submitted in writing to EPA by John Olmsted (RTE Corporation) undated.
4. Letter from James Thompson (T&R Electric Supply Company, Inc.) to EPA dated August 28, 1978.
5. "Response to June 7, 1978 Federal Register Regarding Proposed Change in PCB Regulations" submitted to EPA by Stanley Meyers (Transformer Consultants) as an attachment to letter dated September 13, 1978.

Electric Institute (EEI) also summarized this information. The EEI summary is included as Tables 6.1-3 and 6.1-4. Since the EEI tables use a different definition of distribution transformers (including more than just the pole mounted units) and include the results of sampling of oil storage tanks in the totals, the resulting tables are not directly comparable to 6.1-1 and 6.1-2. However, the EEI apparently had access to some data on oil-filled transformers that was not otherwise presented to the EPA.

The only data on contamination of oil-filled transformers that were based on a reasonably random sample of transformers presently in service were the data reported by Allegheny Power, Commonwealth Edison, and TVA. The samples taken by Duke Power were from a population that excluded the large transformers which Duke Power believed were not contaminated. The other utilities sampled on the basis of convenience, usually sampling transformers that were in the shop for repairs or that were being serviced in the field. RTE Corporation reported data based on a planned random sample of transformers which they had built. Although RTE reportedly has never used PCBs in their manufacturing plant, they reported that the level of PCBs seen in transformers was higher in the older units than in newer ones (none of the transformers was found to be contaminated in concentrations above 50 ppm). T&R reported a random sample of used transformers and stated that they felt that the average concentration of PCBs in oil was above 50 ppm because their holding tanks for reclaimed oil contained more than 50 ppm PCBs. GE and Transformer Consultants reported the results of analyses done on their own samples and for other companies; these data may have also been reported by the owners of the transformers and may therefore be duplicate information.

It is not possible to calculate statistics that describe all transformers from the data that has been reported because of problems in sampling protocols, possible double reporting of data, and uncertainties

Table 6.1-3

Edison Electric Institute Summary of Contaminated Transformer Data Submitted by Electric Utilities*

	Distribution[1]		Power		Total[2]		
	No.	> 50 ppm	No.	> 50 ppm	No.	> 50 ppm	> 500 ppm
Comm. Ed.	26	-	17	5	43	5	-
TVA			34	2	38	2	
Consumers					33	4	
Duke			161[3]	51	161	51	3[4]
Allegheny	2	-	20	2	39	9	
GPU			-	-	76[5]	17	2
Georgia			24	-	24	-	
Detroit			4	2	14	2	
Dayton	9	-	17	5	26	5	
Boston Ed					1	-	
Ottertail					1	-	
TOTAL	37	0	277	67	456	95	5
		0%		24%		21%	1%

* Source: Letter from William Gerstner and John Kearney (Edison Electric Institute) to EPA dated October 10, 1978. Appendix B. Appended notes also from Edison Electric Institute.

Notes to Table 6.1-3

1/ See ANSI/IEEE C-57.80 (1978). This definition includes but is not limited to pole-type and residential pad-type transformers.

2/ Includes oil storage facilities and other PCB articles.

3/ As indicated by Duke Power Co. in its hearing testimony (August 21, 1978, at Tr. 113) its sampling program was not representative of its system. Rather, it was designed to sample those transformers "most likely to be PCB-contaminated." Id.

4/ As indicated in the Duke Power Co. Hearing Testimony (Aug. 21, 1978, Tr. at 134) the 3 samples indicating concentration greater than 500 ppm were from transformers manufactured by the same company at least one of which was incorrectly filled with askarel by the manufacturer. Id. at 129. We strongly believe that any contamination greater than 500 ppm is most unusual and unique and is not at all representative of the 35 million mineral oil transformers.

5/ Includes 58 transformers not identified as to power or distribution of which 15 (26%) contained mineral oil dielectric contaminated with PCBs at levels greater than 50 ppm.

Table 6.1-4

Edison Electric Institute Summary of Contaminated Transformer Data

Submitted by Transformer Companies * (1)

	Distribution[2/]		Power		Total		
	No.	>50 ppm	No.	>50 ppm	No.	>50 ppm	>500 ppm
General Electric[3/]	261[4/]	20	13	6	294	37	
RTE	19	-			19	-	
T & R Electric[5/]	14[6/]	6			14	6	
Transformer Consultants[7/]			434[8/]	185	434[9/]	205	65
TOTAL	294	26	447	191	761	248	65
		9%		43%		33%	15%

* Source: Letter from William Gerstner and John Kearney (Edison Electric Institute) to EPA dated October 10, 1978. Appendix C. Appended notes also from Edison Electric Institute.

Notes to Table 6.1-4

1/ Westinghouse has not provided any independent evidence in its comments of the contamination of mineral-oil transformers with PCBs. Its evaluations are solely based on assumptions it makes using the comments and testimony of others for the purpose of demonstrating the economic impact of the proposed regulations.

2/ See ANSI/IEEE C-57.12.80 (1978). This definition includes but is not limited to pole-type and residential pad-type transformers.

3/ GE admits that it has "no idea how to tackle the problem of what percentage of the oil is contaminated" and that "no statistical basis for any conclusion exists in General Electric." R.C. Osthoff, letter to Dr. E.L. Simons (July 3, 1978). In particular, the assertion on page 5 of its Main Comments that 3-10 million pole-type distribution transformers may contain in excess of 50 ppm PCBs is without foundation.

4/ Includes 75 pole-type transformers of which 4 (5%) were above 50 ppm.

5/ T&R Electric buys and sells used transformers. Its sample survey is not statistically "representative" of its inventory, the electric utility industry, or the class of 35 million mineral-oil transformers.

6/ Pole-type transformers. See August 28, 1978 Tr. at 126.

7/ Transformer Consultants is a transformer servicing company. Transformer Consultants has orally informed us that it has now analyzed roughly 2,000 oil samples of which approximately 33% contained greater than 50 ppm PCBs and 10% contained greater than 500 ppm PCBs. Inasmuch as roughly two-thirds of its customers are industrial and the remainder are small utilities, none of the samples conducted by Transformer Consultants is representative of the electric utility industry.

8/ Generally transformers of 200 kva or greater.

9/ See, Reply Comments of Transformer Consultants (September 13, 1978). Note: These numbers differ from those submitted by Mr. Westin on September 26, 1978.

about the analytical methodology that was used in each case. However, from inspection of the data, it might be reasonable to conclude that from 5% to 40% of pole mounted transformers and from 20% to 30% of other oil-filled transformers are contaminated with PCBs in concentrations exceeding 50 ppm. Contamination to levels above 500 ppm appears to be rare. Table 6.1-5 summarizes calculations of the amount of PCBs in all transformers and the amount present in transformers contaminated above 50 ppm. Because of the uncertainties in the data, the range of confidence in these estimates must be at least a factor of four, i.e., each estimate should be bounded by a range of -80% to +400%.

Approximately 80% of the oil-filled transformers are owned by electric utilities, including the 149 class A and B operating companies and approximately 1000 Rural Electric Cooperatives.* About eight million of the pole mounted transformers are owned by the 1000 rural systems, of which 950 are distribution cooperatives that do not generate any power* and that therefore do not have high efficiency boilers.

6.2 Requirements of the PCB Ban Regulation

The regulation defines a class of PCB equipment called "PCB Contaminated Transformers" and specifies certain exemptions from the marking, disposal, and ban requirements that apply to other PCB equipment. "PCB Contaminated Transformers" include (1) transformers which were not originally filled with a PCB coolant liquid but that now are known to contain a liquid contaminated with PCBs in concentrations from 50 ppm to 500 ppm, (2) oil-filled tranformers that have not been tested for PCBs, and (3) transformers that were originally filled with PCB based askarel but that have been decontaminated to the extent that the concentration of PCBs is found to be below 500 ppm when tested after at least three months of service following the last decontamination procedure.

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*Ives, Joseph S. (National Rural Electric Cooperative Association). Written statement dated August 7, 1978, and oral testimony at August 21, 1978 hearing.

Table 6.1-5

Estimated Amounts of PCBs in Oil-Filled Transformers

	Pole Mounted	Other
Average oil capacity, gallons per transformer*	16 gal.	250 gal.
x 7.6 = lb oil per transformer	121.6 lb	1900 lb
Number of transformers in service*	30,000,000	5,000,000
% above 50 ppm	10%	25%
Number of transformers above 50 ppm	3,000,000	1,250,000
Pounds of oil in contaminated transformers	364.8 million lb	2,375 million lb
Assumed average PCBs concentration	80 ppm	80 ppm
Pounds of PCBs in contaminated transformers	29,184 lb**	190,000 lb**
Number of transformers below 50 ppm	27,000,000	3,750,000
Pounds of oil in non-contaminated transformers	3,283 million lb	7,125 million lb
Assumed average PCB concentration	10 ppm	20 ppm
Pounds of PCBs in non-contaminated transformers	32,830 lb**	142,500 lb**
Total pounds of PCBs	62,000 lb**	332,500 lb**

Total 400,000 lb PCBs**

*Versar, 1978, pp. 36-40

**Confidence limits: - 80% + 400%

The following provisions apply to "PCB Contaminated Transformers":

- Continued use: defined as use in a totally enclosed manner, and therefore not regulated.

- Marking: exempted from the requirement that a PCB label be applied.

- Servicing and rebuilding in other than a totally enclosed manner: authorized until July 1, 1984, provided there is no change of ownership of liquid containing over 50 ppm PCBs. (Note: reclaimed transformer oil may be presumed to contain between 50 and 500 ppm PCBs unless it has been tested.)

- Reclaiming used transformer oil: authorized without restriction for use by the owner of the oil in his own transformers.

- Sale of reclaimed transformer oil: tested and found to contain less than 50 ppm PCB: not regulated.

  Not tested for PCBs or tested and found to contain 50 to 500 ppm PCB: banned after June 30, 1979, unless EPA grants an exemption from the "distribution in commerce" bans. EPA has not yet announced the conditions under which individual and consolidated petitions for exemption will be accepted.

- Resale of used transformers: excluded by TSCA from the "distribution in commerce" ban.

- Disposal of drained transformers: not restricted.

- Disposal of used transformer oil: tested and found to contain no detectable PCBs: not regulated. (Testing may be performed on batches of oil from different transformers, i.e., testing of storage tanks is permitted.)

  Tested and found to contain detectable PCBs in concentrations below 50 ppm - not regulated, except the oil may not be used as a sealant, coating, or dust control agent (i.e., not allowed as road oil or pesticide carrier).

Not tested or tested and found to contain 50 to 500 ppm PCBs: storage and shipping containers must have PCB label. Storage must be in special PCB storage areas and shipping vehicles must be marked. Disposal must be in one of the following:

(1) In an approved PCB incinerator.

(2) In an approved chemical waste landfill.

(3) In a large (50 million BTU per hour or larger) high efficiency boiler that meets certain specified operating criteria. The EPA Regional Administrator must be notified 30 days before the first time PCB contaminated oil is burned.

(4) By any other method that has been demonstrated to have as high a destruction efficiency for PCBs as does a high efficiency boiler and that has been approved for disposal of PCB-contaminated oil by the EPA Regional Administrator.

6.3 Cost Impacts of the PCB Ban Regulation

The regulation does not affect the continued use or resale of PCB contaminated transformers, nor does it affect the maintenance of these transformers except to ban the sale of reclaimed contaminated fluid. The only impacts will be on the reclamation and disposal of contaminated used transformer oil and other contaminated transformer liquids.

July 1, 1984 deadline on rebuilding oil-filled transformers:

After July 1, 1984, rebuilding of oil-filled transformers will only be allowed for those units that have been tested and found to contain less than 50 ppm PCBs. It is anticipated that EPA will review the status of the rebuilding of transformers and the occurrence of PCBs in the oil of oil-filled transformers prior to the 1984 deadline. Those companies that rebuild transformers will therefore have to stay in close contact with EPA and participate in the regulatory review process in order to ensure that this deadline does not result in major unforeseen economic impacts. There is not sufficient information to support any estimate of the costs to be incurred by the transformer service industry and by the users of oil-filled transformers by participating in the eventual review of these regulations.

Reclamation of used fluid from PCB contaminated transformers:

According to Duke Power Company, reclaiming and reprocessing transformer oil saves at least $.40 per gallon on the 170,000 gallons of oil which they reprocess in-house each year.* The Cincinnati Gas and Electric Company reported that they salvage 60,000 gallons of used transformer oil each year from their transformer repair operations and that this is reprocessed into 58,000 gallons of useable oil at a total cost of $18,000 or $.31 per gallon.** New transformer oil presently costs about $1.19 per gallon** and the price is expected to increase over the next few years as supplies of naphthenic crude oil are depleted and transformer oil must be made by the more expensive process of deeply dewaxing paraffinic crude oil fractions.

Not all used transformer oil is reclaimed because smaller transformer companies and utilities do not generate enough used oil to justify the purchase of the necessary equipment. However, reclamation appears to be the standard practice for most transformer repair shops and major utilities. The regulations authorize the reclamation of used transformer oil by utilities for use in their own transformers. The regulation requires that all transformer oil be presumed to contain more than 50 ppm PCBs unless it has been tested and found to contain less than 50 ppm PCBs. The sale of reclaimed transformer oil is banned after June 30, 1979, unless each batch has been shown to have less than 50 ppm PCBs or EPA exempts the seller from this ban requirement. The EPA has not yet established the basis on which it will accept individual or consolidated petitions for exemption, nor has it announced the basis for granting such exemptions. The filtering of oil by transformer service companies as a part of routine field maintenance is allowed because the oil is returned to the transformer from which it is taken and ownership of the oil does not change, so there is no "distribution in commerce" taking place.

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*"Duke Power Company's Response..." dated August 4, 1978. Submitted to EPA as a written main comment on the proposed PCB ban regulation.

**Letter from E. E. Galloway (The Cincinnati Gas and Electric Company) to EPA dated August 4, 1978.

As calculated in Table 6.3-1, approximately 78% of the transformer oil is in transformers owned by large utilities, most of which do their own routine maintenance.

Maintenance of most of the transformers not owned by the major utilities is performed by transformer manufacturers and by independent repair shops. About 8 million of the 30 million pole mounted distribution transformers are owned by small distribution utilities most of which do not repair their own transformers. As calculated in Table 6.3-1, the effect of the ban on the sale of reclaimed oil is to eliminate the opportunity to recycle 22% of the available oil unless each batch is tested and shown to contain less than 50 ppm PCBs. If it is assumed that 4% of all oil becomes available for recycling each year (equivalent to assuming an average of 25 years between major servicing operations on each transformer) and that 75% of the oil was actually recycled, savings in 1978 would have been (1.73 billion gallons x 4% available x 75% reclaimed x \$.40 to \$.80 per gallon savings per gallon reclaimed =) \$20.8 million to \$41.5 million. The cost of the foregone savings from recycling in 1979 could be as much as 22% of the 1978 savings, or \$4.6 million to \$9.2 million.

The actual reduction in the amount of oil reclaimed by transformer shops will depend on the economics involved in testing the oil to demonstrate that each batch contains less than 50 ppm PCBs. The total amount of oil that could be reclaimed for purposes of resale by transformer maintenance shops might be 11.4 million gallons per year as calculated in Table 6.3-2. If this oil were accumulated in 1000 gallon batches prior to

Table 6.3-1

Used Transformer Oil Available for Reclamation

	Pole Mounted Transformers	Other
Average capacity-gallons	16	250
Total number in service	30,000,000	5,000,000
Owned by industry	-	900,000
Owned by small utilities	8,000,000	100,000
Owned by major utilities	22,000,000	4,000,000
Amount of oil in use	480 million gal	1,250 million gal
Total	1,730 million gal	
Amount of oil used by major utilities	352 million gal	1,000 million gal
Total	1,352 million gal	

Percent of transformer oil used by major utilities:

$$\frac{1{,}352 \text{ million gal.}}{1{,}730 \text{ million gal.}} = 78\%$$

Percent of transformer oil not available for recycling: 1-78% = 22%

Table 6.3-2

Estimated Supply of Transformer Oil Available for Recycling for Sale

Total amount of oil	1.73 billion gallons
x fraction available each year	4%
x fraction to transformer repair companies	22%
x fraction assumed recoverable (not too degraded by prolonged use)	75%
= Total annual supply of oil available for recycling for sale	11.4 million gallons

testing, all of the oil could be tested for PCBs by performing 11,400 analyses. Costs of such a routine sampling and analysis program were previously estimated to be from $67 to $80 per sample (Versar 1978, p. 41). The cost of performing such an analysis on a 1000-gallon tank full of oil would be only $.08 per gallon. Testing to prove that the oil could be reclaimed would be justified as long as the expected cost per gallon reclaimed is less than the cost savings of $.40 per gallon achievable by reclaiming the oil. Therefore, the analysis of 1000-gallon batches would be justified if as few as one of every five batches were actually found to have less than 50 ppm PCBs. If the total amount of PCBs in transformers is actually the 400,000 pounds estimated in Table 6.1-5, the average concentration of PCBs in the 1.73 billion gallons of transformer oil that is in use would be about 30 ppm. This implies that at least one half of the batches of oil that are tested would have less than 50 ppm PCBs if care were taken to avoid contamination of the oil with materials used with askarel transformers. If only one half of the batches were in fact contaminated to levels of less than 50 ppm, an expenditure of (11,400 analyses at $80 =) $912,000 for chemical analyses would make available (11.4 million gallons x 50% =) 5.7 million gallons of oil per year for recycling and resale. If the recycling of this oil saves $.40 to $.80 per gallon, the total cost of the ban on selling untested recycled transformer oil would be reduced by (5.7 million gallons x $.40 to $.80 per gallon - $912,000 testing cost =) $1.368 to $3.468 million per year. Total costs would then be ($4.6 to $9.2 million - $1.4 to $3.6 million =) $3.2 to $5.6 million per year. If, however, none of the batches of oil had over 50 ppm PCBs, the total cost of the regulation would be the cost of the analyses (or a total of $912,000 per year if testing were performed on batches of 1000 gallons) or even less if the average batch size were larger.

Disposal: The PCB Ban Regulation authorizes the disposal of transformer oil contaminated with 50 to 500 ppm PCBs in large, high efficiency boilers meeting certain requirements of size, feed rate of the contaminated oil, presence of excess oxygen in the stack gas, specified instrumentation and monitoring procedures, and other specified operating conditions. The contaminated oil would have to be handled and labeled as PCBs during shipment and storage.

The regulations require that the EPA Regional Administrator be notified at least 30 days before the first time each high efficiency boiler is used to burn transformer oil known or presumed to be contaminated with PCBs. The regulations further state that the contaminated oil cannot be fed into the boiler during start-up or shut-down conditions and that the oil can comprise only ten percent of the fuel while the boiler is operating. Therefore, special holding tanks and metering pumps will be required to feed the transformer oil into the fuel stream in a controlled amount during periods of stable operation of the boiler.

A number of utilities have stated that they have power boilers that operate at combustion conditions similar to those specified for PCB incinerators.* A special holding tank and metering pumps will be required to feed contaminated transformer oil into a high efficiency boiler. Additional road construction, fencing, or other utilities may add to the cost of equipping a boiler to burn transformer oil in compliance with the regulation. This expenditure would probably only be made if justified by savings resulting from (1) decreased disposal costs and (2) the value of heat recovered in burning the transformer oil.

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*Letter from Nancy Gormley (Allegheny Power Service Corporation) to EPA dated August 4, 1978.

*Letter from James Mulloy (City of Los Angeles Department of Water and Power) to EPA dated August 7, 1978.

*Attachment to letter from L. John Cooper (Nebraska Public Power District) to EPA dated August 4, 1978.

*"Comments of Otter Tail Power Company on the Proposed Amendments to 40 CFR 761." Submitted to EPA by Jay D. Myster, undated.

*Letter from S. A. Ali (Public Service Indiana) to EPA dated August 4, 1978.

Disposal of used transformer oil in approved high temperature PCB incinerators has been quoted to cost \$.08 per pound in tank truck lots (Rollins, 1978) plus perhaps \$.02 per pound transportation (Versar, 1977, pp. 2-32). This is roughly \$.75 per gallon. T&R Electric estimated that fuel oil to replace transformer oil used in their boiler would cost \$.42 per gallon.* Shipping costs to move transformer oil in drums to boilers equipped to burn it will probably not exceed the commercial trucking costs of \$2.70 per hundred pounds for trips under 100 miles (Versar 1977, p. 2-33). For transformer oil weighing 8 pounds per gallon, this is equivalent to (\$2.70/8 =) \$.34 per gallon. Shipment of large quantities by tank truck would be considerably cheaper per gallon. The value of the oil to the company that owns and burns it would be equal to the savings in disposal cost (\$.75 per gallon) plus the net fuel value (\$.42 -\$.34 = \$.08 per gallon). Even though most utilities might be able to obtain fuel for their power boilers at a lower cost than is paid by T&R Electric, the savings in disposal cost of \$.75 per gallon could quickly pay for the estimated cost of installing additional handling facilities at the boiler.

Since the value of used transformer oil as fuel is roughly equal to the cost of handling and transporting it, the total cost of disposal to those utilities that have suitable boilers will be the cost of equipping the boilers. There is not sufficient information in the record to support an estimate of the cost of installing this equipment, but this alternative disposal method should be considerably cheaper than commercial approved PCB incineration for most of the 149 class A and B utilities.

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*Letter from James Thompson (T&R Electric Supply Company, Inc.) to EPA dated August 28, 1978.

Satisfactory high efficiency incinerators will not be generally available to the many distribution utilities, transformer repair shops, and industrial owners of oil-filled transformers. For instance, T&R Electric is a transformer repair shop that burns 200,000 gallons of used transformer oil each year in a hot water generator which has a flame temperature of 1700° F.* The regulations will require that this oil be disposed of by incineration in high efficiency boilers or by other approved methods. This will result in increased costs to T&R Electric both to dispose of this oil and to replace it.

If the requirement that waste oil be labeled as PCBs discourages general handling of this material, the value of the used oil to the company that generates it may be considerably less than its potential fuel value. The result may be disposal costs of up to $.75 per gallon. Since much of the waste oil is now used as supplemental fuel in small boilers that will not meet the requirements established by the regulation, the opportunity cost of the regulation may be up to ($.75 disposal cost + $.42 fuel value =) $1.17 per gallon of the oil that is incinerated in approved PCB incinerators.

The discussion of reclamation of used transformer oil concluded that the value of reclaimed oil was such that testing of batches of oil to demonstrate that the PCB content is below 50 ppm will be justified for most of the transformer repair shops. The oil that will require disposal will be those batches found to be contaminated above 50 ppm, that oil which has degraded past the point where reclamation is feasible, and the oil generated in small batches by junk yards and other industrial concerns that handle transformers infrequently. It was estimated above that 5.7 million gallons per year of available oil would be salvageable and contain less than 50 ppm PCBs.

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*Letter from James Thompson (T&R Electric Supply Company, Inc.) to EPA dated August 28, 1978.

The maximum economic cost would be incurred if the remaining oil were disposed of in approved high temperature PCB incinerators. The total annual cost of this incineration is calculated in Table 6.3-3 to be $11.1 million per year. This total would be reduced considerably if the large utilities were willing to accept contaminated oil for burning in high efficiency boilers from other sources, but the comments to the EPA by the utilities did not express any interest in making this service generally available.

The willingness of large utilities to make available their high efficiency boilers for burning used transformer oil may be increased by the willingness of the small utilities and transformer repair shops to pay up to $.75 per gallon for this service. The large utilities would incur no cost other than the cost of supervising the transfer of truck loads of liquids to their storage tanks and the monitoring and record keeping costs that are incurred by the regulations on any disposal of PCBs. Given a perfect market, the large utilities might be expected to be willing to pay for the fuel value of the used oil. However, the market is likely to be very imperfect, and the actual price charged by the utilities for this service can therefore not be predicted. However, since the burning of oil by the large utilities will not cost them anything, the price that is charged will represent a transfer payment from the small transformer shops and distribution utilities to the large utilities, and will not represent a real economic cost. Real economic costs would result only from the higher transportation costs of moving the oil to the large utilities and from the greater value of the heat content of the oil to the smaller companies than to the large utilities. These economic costs are likely to be only a small fraction of the costs incurred by incineration of this oil in approved PCB incinerators.

Marking and Storage Costs: The change in the definition of PCB material from a concentration of 500 ppm to a concentration of 50 ppm extends the impact of the PCB Marking and Disposal Regulations to all used

TABLE 6.3-3

Cost of Disposal of Transformer Oil from Small Utilities, Transformer Repair Shops, and Other Sources

	Total Amount of Transformer Oil in Service	1.7 billion gal.
x	Amount Available Each Year	4%
x	Amount Not Owned by Large Utilities	22%
=	Amount Available Per Year	15.2 million gal.
-	Amount Reclaimed and less than 50 ppm PCBs	5.7 million gal.
=	Total Available for Fuel	9.5 million gal.
x	Cost of Incineration and Lost Fuel Value	$1.17 per gal.
=	Maximum Cost Per Year:	$11.1 million per year

transformer oil that is being stored for disposal or reuse and to the oil that is being transported for disposal. At a very minimum, special PCB storage areas will be required at each of the 149 large utilities that maintain their own transformers. These major storage areas were previously estimated to cost $2000 to construct and to result in annual operating costs of $2,125 per year (Versar, 1977, pp. 2-6). Total costs incurred because of the inclusion of transformer oil may therefore be equal to ($2000 per site x 149 locations =) $300,000 in initial construction costs and ($2125 x 149 =) $320,000 per year thereafter. The regulation also permits bulk storage of used transformer oil and the provisions of the Spill Prevention Control and Countermeasure (SPCC) plans of the oil spill prevention program become the storage criteria. Since almost all utilities have SPCC plans, this option probably results in no additional costs being incurred.

Additional marking costs will be incurred in applying PCB labels to drums, tanks, and trucks used to transport used oil to the disposal sites. Because any tank used to contain transformer oil must be considered to be a PCB container, special decontamination will be required before it could be used for any other service. Therefore, it is likely that each high efficiency boiler facility will have a dedicated truck trailer tank that is used to haul PCBs. Application of labels to these tanks will cost only a few dollars per year.

6.4 PCBs Controlled by the Regulation

A certain amount of used transformer oil has been used in the past as fuel in various boilers and power generating units. When possible, the oil has been reclaimed for use in transformers. Other uses include road oiling and re-refining into lubricating oil. Only a very rough estimate can be made of the amount of PCBs released to the environment by past practices in handling used transformer oil.

If it is assumed that past practices resulted in the use of one-half of the oil as fuel in boilers operating at conditions that destroyed 98% of the PCBs present and that the remaining PCBs would eventually enter the environment, the burning would have been expected to destroy (.98 x .5 x 400,000 lb PCBs =) 196,000 pounds of the PCBs in transformer oil. The effect of the regulation is to require the eventual disposal of all transformer oil in high efficiency boilers that will destroy 99.9% of the PCBs present. Therefore, PCB releases to the environment may be reduced from (400,000 - 196,000 =) 204,000 pounds to (400,000 x [1 - .999] =) 400 pounds, or a net reduction of about 200,000 pounds of PCBs.

6.5 Summary - Economic Impacts:

Ban on reclaiming oil for resale:	$3.2 million to $5.6 million per year (may be reduced if EPA exempts processing and resale from the ban requirements).
Limitations on disposal of contaminated transformer oil:	
Cost of storage tanks, etc., at high efficiency boilers:	cannot be estimated from information in the record.
Cost of incinerating oil generated by other than large utilities:	Up to $11.1 million per year if large utilities do not accept oil for burning in their boilers. Cost may be reduced considerably if large utilities make this service available.
Cost of special storage area for transformer oil at utilities:	$0 to $300,000 initially plus $0 to $320,000 per year starting 30 days after promulgation of the regulation.

6.6 Cost Per Pound of PCBs Kept from the Environment

If it is assumed that the restrictions on disposal and reclaiming of transformer oil will continue for the 30 year life of the newest oil filled tranformers:

Ban on reclaiming and special disposal requirements =

$$\frac{\$3.2 \text{ million to } \$5.6 \text{ million} + 0 \text{ to } \$11.1 \text{ million} + 0 \text{ to } \$.3 \text{ million}}{200{,}000 \text{ lbs/30 years}} = \$480 \text{ to } \$2550 \text{ per pound PCBs}$$

7.0 IMPACTS ON TRANSFORMER SERVICE COMPANIES

7.1 Present Status

There are presently about 300 small companies that service the transformers owned by small utilities and by industry.* The services offered by these companies include field testing and servicing of transformers and complete shop maintenance and rebuilding services.

7.2 Requirements of the Regulation

The regulation requires that all oil-filled transformers be considered to be PCB contaminated transformers unless the concentration of PCBs in the oil has been demonstrated by chemical analysis to be less than 50 ppm. The regulation bans the sale of any new or reclaimed transformer liquids unless they are known to contain less than 50 ppm PCBs.

7.3 Impact of the Regulation

The major impact of the regulation on the small transformer service companies results from the change in the definition of PCBs from a concentration level of 500 ppm to a level of 50 ppm. Many of these companies have discontinued servicing askarel transformers because of the potential liability that could result from spills or worker exposure, and because of the relatively high price of building the required storage areas for PCB materials. Companies who do not have oil storage facilities meeting SPCC requiraements are now required to install special storage areas for the storage of oil filled transformers and used transformer oil.

Transformer service companies will face increased costs from the ban on reclaiming PCB contaminated transformer oil for resale, and increased disposal costs. These costs were discussed in detail in Chapter 6, and the companies should be able to pass them along to their customers. The fact that the regulation allows reclamation of PCB contaminated oil for use in the owner's transformers but not for resale will provide an economic incentive for utilities and large industrial concerns to perform their own maintenance rather than contract it out. However, there is not sufficient information available to support any quantitative estimate of the resulting market shifts. The economic impact of restrictions on these activities will be dependent on the extent to which EPA grants exemptions for these activities.

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*Letter from Robert L. Sandman (Electric Apparatus Service Association) to EPA. Undated.

7.4 PCBs Controlled by the Regulation

There was no information presented on the amount of PCBs entering the environment as the result of improper storage of transformer oil by transformer service shops. Therefore, no estimate can be made of the reduction of PCBs entering the environment that will result from the improvement of storage conditions at these facilities.

7.5 Summary - Economic Impacts

Information is not available from the record to make estimates of these impacts.

8.0 MINING MACHINERY*

8.1 Current Use of PCB-Cooled Mining Machinery Motors

In the late 1960s and early 1970s, PCBs were used as a motor coolant in three types of electric motors manufactured by Reliance Electric for Joy Manufacturing Company. Joy used these motors in three models of low seam mining machinery: CU43 continuous miners, 9CM continuous miners, and 14BU10 loaders. Table 8.1-1 summarizes the production statistics and present usage of these machines.

One small coal mining company in Pennsylvania is operating the three remaining Model CU43 continuous miners known to be in service. This company also has portions of several other CU43 miners which they have purchased for parts. Two of the machines in use have had the PCB-coolant replaced with a silicone fluid and two of the three motors on the third miner have also been filled with silicone. If the motors were not completely cleaned and rewound at the time the silicone fluid was introduced, it is probable that the motors still contain low levels of PCBs. For the purposes of this analysis, it will be assumed that they are contaminated with PCBs at levels in excess of 50 ppm. Fifty-four of the fifty-seven 9CM continuous miners sold in the United States were located by Versar during the course of a telephone survey. Two of the three machines which could not be located were recently sold on the used-machinery market. It is assumed that these two machines are still in use. Thirty-five of the model 9CM miners are currently idle, fifteen are being used to mine coal, three are in use for maintenance or construction, two are in use on spare sections, and one is being used in a training program at a vocational school.

The 14BU10 loaders were originally sold to eighty-eight different mining operations, the majority of them small; sixty of these mines have three or fewer of these loaders. Based upon the expected service life of the machines and a survey of thirty-six mines, it is estimated that essentially all of these loaders are still in service.

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*All figures and information in this Chapter are from Versar, 1978, except where noted.

Table 8.1-1 Use of PCB-Cooled Electric Motors in Mining Machinery[1]

Machine	Number Produced	Number Still in Service with PCB Motors	Number of PCB Motors per Machine	Total PCB Motors	Number of Gallons of PCBs per Motor	Total Gallons of PCB per Machine	Total Gallons PCB
CU43 Continuous Miner	17	3	3	9	4	12	36
9CM Continuous Miner	57	15 + 6 (3)	3	63	5	15	315
14BU10 Loader	533 (2) + 34 Spare Motors	250 (4) + 17 (5)	2	517	4	8	2,068

(1) Except as noted in (3) and (4) below, all data is from Versar, 1978.

(2) Approximately 280 of these machines now have air-cooled motors.

(3) 15 in use for production, 6 for other uses

(4) Oral Comments of Mr. A. R. Benvenuto (Joy Manufacturing Company) at the PCB Ban Regulation Hearings, August 25, 1978.

(5) Estimated, based on percentage of loaders that have been converted.

For the past few years, Joy has been converting the motors on the loaders to air-cooling. As shown in Table 8.1-1, there are approximately 250 loaders and 17 spare motors that still contain PCBs.

The motors on the continuous miners and the loaders require occasional topping-off with additional fluid at the mines. The amount of fluid which is required is small but is necessary for the continued operation of the machines.

8.2 Requirements of the Regulations

The PCB Ban Regulations require or permit the following with respect to the continued use and servicing of PCB-cooled mining machinery motors:

- PCBs may be used in mining equipment until January 1, 1982.
- PCBs may be added to mining equipment motors at the mines until January 1, 1982.
- PCB motors in the loaders must be rebuilt as non-PCB cooled motors whenever the motors are returned to a service shop for servicing.
- PCB motors on continuous miners may be rebuilt as PCB motors until January 1, 1980.
- Any PCBs used to service or repair PCB-cooled motors must be stored in accordance with the storage for disposal requirements of Annex III (§761.42).
- Processing and distribution in commerce of PCBs for purposes of servicing mining equipment is permitted after July 1, 1979, for persons who are granted an exemption under TSCA §6(e)(3)(B).

8.3 Compliance Costs

Continuous Miners: The regulations allow rebuilding of the motors in the two models of Joy continuous miners as PCB motors until July 1, 1979. This deadline could be extended to January 1, 1980, if EPA grants the service shops an exemption from the "processing" and "distribution in commerce" bans. There are no non-PCB motors that can be used in place of the PCB motors on the continuous miners, and space limitations on the machines prevent converting these motors to air cooling. Since the PCB motors on the continuous miners require rebuilding after about 12 months of service*, all of these machines will have to be retired from use within about a year after the effective date of the ban on rebuilding the motors.

Because of the time limits in the authorization, the market for used 9CM and CU43 continuous miners will virtually disappear. Though this machinery may be technologically obsolete before January 1, 1982, there are undoubtedly numerous small firms which cannot afford the capital investment required for new machinery and thus rely on older used machines to fill their needs. In addition, larger firms often use older machinery for spare equipment or in mine construction. Therefore, the owners will be confronted with equipment that they must retire prematurely, losing the remainder of the machine's useful life or the income that could result from the sale of the machinery.

Eight companies still use 9CM or CU43 continuous miners for coal production. Six of these companies are relatively small, with production ranging from 0.7 to 4.2 million tons per year. The other two are large conglomerates with much higher annual productions. In addition, six machines are performing operations other than production. The market value of these machines is roughly $40,000 each (Versar, 1978). Table 8.3-1 summarizes the costs that would be incurred by each of the companies that still use the continuous miners for coal production. Table 8.3-1 omits the 42 miners that are idle or in non-production uses because the percentage of those miners that have any value is not known. If each of them has a value

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*Testimony of Mr. Ed Warner (Joy Manufacturing Co.) at the EPA PCB Hearings, Chicago, Illinois, July 19, 1977.

TABLE 8.3-1

Cost Impact of Forced Retirement of PCB Continuous Miners

Company No.	Number of Continuous Miners Model CU43	Number of Continuous Miners Model 9CM in Service	Opportunity Cost Due to Absence of Used Equipment Market
1*	3	0	$ 120,000
2*		3	$ 120,000
3*		2	$ 80,000
4*		1	$ 40,000
5		1	$ 40,000
6*		1	$ 40,000
7		2	$ 80,000
8*		5	$ 200,000
(Other Uses)		6	$ 240,000
TOTAL	3	21	$ 960,000

* Small producer (less than five million tons per year total company production).

of $40,000, the additional cost could be as much as $1.7 million. In no case does the economic impact exceed one percent of the value of the coal mined annually by any of the affected companies. It is assumed that replacement machinery could be obtained in time to prevent any interruptions in coal production.

Loaders: The PCB motors used on the loading machines can be converted to air cooling at a cost of $3,100 per motor. The motors usually require rebuilding after 18 to 24 months of service*, so most of the motors will be available for this conversion without incurring additional downtime for the machines. Joy Manufacturing Company has stated that its service shop has the capacity to convert all of the PCB motors presently used on loaders to air cooling by the end of 1981. Since the PCBs will be removed from these motors for purposes of disposal, this activity is not affected by the ban on "processing" of PCBs.

The total cost to convert the 517 PCB motors used on the loaders will be (517 x $3,100 =) $1.6 million. There should be no interruption of coal production due to the conversion program because PCB motors will be allowed to continue in use until January 1, 1982, and most of the conversions will occur when the motors will require normal rebuilding. It is anticipated that maintenance requirements will be greater for the air cooled motors than for the PCB cooled motors, but it is not possible to estimate the total economic impact of the resulting increased maintenance costs.

Storage Costs: Each mine would be required to store PCBs used for maintenance in a storage area that meets the requirements of Annex III. Joy sells the PCBs in one gallon cans. A non-leaking 55 gallon drum protected from the rain would meet the requirements of Annex III and would be of sufficient size to store all the PCBs any mine would require. Each of the 96 companies possibly involved (88 loader owners and 8 continuous miner owners) would need such a storage area. The cost for a barrel and a label may amount to $50 each for a total cost of $4,800. The recordkeeping required for storage areas may increase this cost by a factor of two to three, for a maximum expected cost of $14,400.

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*Testimony of Mr. Ed Warner (Joy Manufacturing Company) at the EPA PCB Hearings, Chicago, Illinois, July 19, 1977.

Exemption Application: It is assumed that Joy Manufacturing will apply for an exemption under TSCA §6(e)(3)(B) in order to be allowed to rebuild the loader motors and to be allowed to distribute PCBs to the mines for maintenance. The estimated $1,600 cost of preparing this petition is developed in the chapter on unintentional product contaminants.

8.4 PCBs Controlled by the Regulation

The electric motors in use on mining machines contain about 2419 gallons of PCBs (Table 8.1-1). This is equivalent to about 27,500 pounds of PCBs with a density of 11.37 pounds per gallon. The regulations will stop the losses of PCBs from these motors by requiring that they be scrapped or rebuilt as air cooled motors by January 1, 1982. There is no information in the record on which to base any estimate of the rate at which PCBs are lost from these motors. Therefore, no estimate can be made of the number of pounds of PCBs that will be prevented from entering the environment.

8.5 Summary-Economic Impacts

Loaders - rebuild motors @$3,100	$1,600,000
Continuous Miners-premature scrapping of 24 operating machines @$40,000	960,000
42 other miners @0 - $40,000	0 to 1,700,000
Storage costs - 96 storage areas	14,400
Exemption application	1,600
TOTAL	$2,576,000

(plus up to $1,700,000
for idle miners)

8.6 Cost Per Pound of PCBs Kept from the Environment

If it is assumed that the regulation will prevent the entry into the environment of all the PCBs presently in use, and that all of the PCBs would otherwise be lost:

$$\text{Cost per pound} = \frac{\$2{,}576{,}000 \text{ to } \$4{,}276{,}000}{27{,}500 \text{ pounds}} = \$94 \text{ to } \$155 \text{ per pound PCBs}$$

9.0 ELECTROMAGNETS*

9.1 Current Usage

Large electromagnets are installed over conveyor belts to remove tramp iron from non-magnetic commodities such as coal and grain. Most of these electromagnets are cooled with 100 to 150 gallons of mineral oil. Where increased fire safety was required, the magnets were often filled with PCB based askarel liquid. The three magnet manufacturers who used PCBs were:

Sterns Magnetics, Cudahy, Wis.
Eriez Magnets, Erie, Pa.
Dings Co., Milwaukee, Wis.

Dings Co. stopped using PCBs in mid-1976; the other two manufacturers have not used PCBs since 1971 or 1972. A total of about 250 PCB magnets were manufactured; approximately 200 of these may still be in use in the United States. Most of the PCB magnets are being used in coal mines, coal preparation plants, and in coal-fired generating stations. It is possible, but not confirmed, that some of the PCB magnets may be used on grain conveyors because of the flammability of grain dust.

The electromagnets are of completely welded construction, and very few leakage incidents have occurred with either oil-filled or PCB-filled magnets. Based on design considerations, electromagnets would be expected to be less likely to fail than transformers. Those leaks that have occurred have been caused by physical abuse or lack of adequate maintenance. Maintenance requirements do not expose workers or the environment to contact with PCBs. Since the magnets are suspended over conveyor belts, diking is not feasible, and any leakage would be uncontrolled. However, PCBs dripping onto the coal would be expected to be destroyed in power generating boilers, thus making the only loss to the environment that of leachate from contaminated coal in storage piles. The total amount of PCBs presently in use in electromagnets is probably (200 magnets x 135 gallons per magnet x 11 pounds per gallon x .7 pound PCB per pound askarel =) 207,900 pounds of PCBs.

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*All information in this chapter is from Versar, 1978, Chapter 9, except as noted.

9.2 Requirements of the PCB Ban Regulations

Continued use: PCB-filled electromagnets are defined as a totally enclosed use of PCBs and therefore may continue to be used indefinitely.

Servicing: Minor servicing which does not require the removal of the coil from the casing is authorized until July 1, 1984. Removal of the coils is prohibited.

Sale of PCBs: Banned after July 1, 1979, unless EPA grants an exemption from the "distribution in commerce" ban.

Reclaiming PCBs: For reuse by the owner of the PCB transformer or electromagnet: authorized. For sale: banned unless an exemption is granted by EPA.

Disposal: By incineration in an approved high temperature PCB incinerator. Drained PCB electromagnets may be disposed of in approved chemical waste landfills; the liquids drained from the magnets must be incinerated in approved incinerators.

9.3 Cost Impacts of the PCB Ban Regulations

Continued use: The regulations impose no additional requirements beyond the labeling previously required by the PCB Disposal and Marking Regulations (EPA, 1978a).

Ban on manufacture: The ban on the manufacture of new PCB magnets is not expected to have a significant impact on either the manufacturers or users of these magnets. According to the magnet manufacturers, the PCB electromagnets could be replaced with oil-filled units at an average cost of $8,000 per magnet. However, the use of mineral oil in these applications would significantly increase the fire risks. The manufacturers regularly furnish silicone-filled magnets for use where more effective fire resistant characteristics are required than those achievable with mineral oil. Such silicone-filled units are 40 to 50% more expensive than comparable oil-filled units; the average cost is $12,000 per magnet. In addition, Eriez offers a proprietary air-cooled electromagnet which has Underwriters Laboratory approval for use in dirty and dusty environments. These units cost an average of $10,000 each.

Servicing: The PCB electromagnets are similar in construction to askarel transformers, and it is anticipated that the magnets are subject to the same failure mechanisms, expected service life, and service practices as the transformers. If the average remaining service life of the PCB electromagnets is ten years, the magnets would be expected to fail at the rate of twenty units per year. Although rewinding failed magnet coils would probably cost 60% of the cost of a new magnet, rebuilding is banned by the regulation. The transportation and labor costs would be expected to be the same whether a magnet is replaced or rebuilt, so the effect of the ban on rebuilding is to forego a potential savings of 40% of the purchase cost of a new magnet each time a PCB magnet fails. Total annual costs would be expected to be (20 magnets per year x 40% of $12,000 per magnet =) $96,000 per year. Total costs attributable to the ban on rebuilding PCB electromagnets will be $960,000.

Disposal: The PCB Ban Regulations authorize the disposal of drained PCB electromagnets in chemical waste landfills. The previous PCB Disposal and Marking Regulations (EPA, 1978a) authorized only incineration. Since incineration is not available for magnets, a petition for alternating disposal means would have had to have been submitted to the EPA each time a magnet required disposal. There is no information in the record on which to base an estimate of the cost of preparing and processing such petitions, but this cost has been eliminated by the Ban Regulations.

9.4 PCBs Controlled by the Regulation

The PCB electromagnets presently in use contain about 207,900 pounds of PCBs. The regulations do not affect the continued use of these magnets. The effect of the ban on rebuilding these magnets will be to eliminate the loss of PCBs to the atmosphere that might occur during the rebuilding process. If these losses were 1 to 10 pounds per magnet, as estimated in Chapter 4 for askarel transformers, the regulations would be expected to reduce the amount of PCBs entering the environment by (200 magnets x 1 to 10 pounds PCBs per magnet =) 200 to 2000 pounds of PCBs.

9.5 Summary - Economic Impacts

Ban on rebuilding: $96,000 per year; $960,000 total.

Disposal: Elimination of costs of preparing and processing petitions for disposal by means other than incineration.

9.6 Cost Per Pound of PCBs Kept from the Environment

$$\text{Cost per pound} = \frac{\$960{,}000}{200 \text{ to } 2000 \text{ pounds}} = \$480 \text{ to } \$4800 \text{ per pound PCBs}$$

10.0 HYDRAULIC SYSTEMS

10.1 Present Use of PCBs in Hydraulic Systems

Prior to 1972, PCB based hydraulic fluids were marketed by Monsanto under the trade name Pydraul® for use in hydraulic systems where superior fire resistance was necessary for protection of life and property.* A previous EPA sponsored study reported that sales of PCB based hydraulic fluids during the period 1970-1971 totaled over 13.5 million pounds to 585 different firms (Versar, 1978, p. 65). General Motors Corporation reported that GM used PCB based fluids in the following types of systems:**

Metal die-casting equipment
Trim press hydraulics
Plastic injection molding machines
Metal melting furnace tilt hydraulics
Industrial elevators
Iron foundry pouring equipment
Molten iron holding furnace equipment
Induction hardening machine hydraulics
Flame hardening equipment
Heat-treating furnace hydraulic systems
Forge furnace hydraulic systems
Forge press hydraulic systems
High tension welding machines
Loading dock levelers
Fork lift trucks
Other small miscellaneous systems.

Uses of PCBs by GM were reported to be: Die-casting - 56%; Foundry - 35%; other uses - 9%. A review of Monsanto's customer list for 1970-71 indicated that 80% of the purchasers of hydraulic fluid were primarily die-casting operations and the other 20% were primarily steel companies (Versar, 1978, p. 65).

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*Hesse, John L. 1975. "Polychlorinated Biphenyl Usage and Sources of Loss to the Environment in Michigan." National Conference on Polychlorinated Biphenyls, November 19-21, 1975, Chicago, Illinois. Washington, D. C.: Office of Toxic Substances, U. S. Environmental Protection Agency (Report No. EPA-560/67-75-004), p. 129.

**Letter from Mr. W. R. Johnson (General Motors Corporation) to EPA dated August 7, 1978.

When Monsanto discontinued the sale of PCB based hydraulic fluids in 1972, they recommended to their customers (1) that there was no need to drain the systems and (2) that compatible Monsanto hydraulic fluids could be used to replace leakage. Most hydraulic systems require the addition of new or reclaimed fluid at a rate of two to ten times the system capacity each year to replace leakage losses. It is fairly common practice to recover leaked fluid and to process it for reuse. Available data on residual PCB levels in hydraulic systems indicate that the concentration of PCBs ranges from 60 ppm to as high as 50% in a few machines (Versar 1978, p. 65). The differences in concentration apparently reflect differences in the rate of leakage from various machines and differing company maintenance policies regarding periodic total replacement of hydraulic fluid.

Mr. Dwain Fowkes of RADCO Corp. reported that the hydraulic fluid which is commercially reclaimed sometimes contains up to 6000 ppm PCBs.* Therefore, it is possible that the use of reclaimed hydraulic fluid has resulted in the PCB contamination of hydraulic systems which never contained PCB based Pydraul® fluids.

Die-casting machines: The analysis of the proposed PCB Ban Regulations suggested that PCB based hydraulic fluid may have been used in as many as 1000 die casting machines. This estimate was based on the assumptions that 80% of the hydraulic fluid sold during 1970-71 was used in die-casting machines, that the annual makeup requirement of new fluid to replace leakage is equal to the liquid capacity of the hydraulic system, and that the average die-casting machine has a capacity of 500 gallons of hydraulic fluid (Versar, 1978, pp. 65-66). Mr. Johnson of General Motors suggested that this estimate may be in error because not all of the hydraulic fluid purchased by companies classified as primarily die-casting concerns was used in die-casting machines; GM used only 56% of their PCB hydraulic fluid in die-casting machines and the rest in associated equipment and in their steel foundry operations.* The Outboard Marine Corporation plant in Waukegan, Illinois, contains 135 die-casting machines, 60 associated trim presses, 30 electric melting furnaces, and several other furnaces plus numerous other systems, all of which contained PCB based hydraulic fluid prior to 1971.** The average capacity of the die-casting machines at Outboard Marine is 350 gallons; GM reported that its die-casting machines had an average capacity of 460 gallons at one plant and 1580 gallons at another plant.

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*Telephone conversation with L. Fourt (Versar), September 19, 1977, as reported in Versar, 1978.

Mr. William Sharp of the Society of Die Casting Engineers stated that die-casting machines are long-lived pieces of equipment with some 35- to 40-year-old machines still in operation. These machines are in use by 1500 to 1800 separate companies, and perhaps 35% of the companies used synthetic hydraulic fluids (not necessarily PCB based). There is a very active market for used machines.***

Based on the available information and assuming that 80% of the companies buying fluid had die-casting machines, that 60% of the fluid purchased by these companies was used in this type of machine, and that the average annual requirement for makeup fluid was equal to the system capacity of 400 gallons, the number of die-casting machines that once used PCB based fluid may have been as high as 700 machines as calculated in Table 10.1-1. No information is available on the number of companies that own PCB contaminated die casting machines. However, it should be noted that not all the machines that used PCB based hydraulic fluid can be identified from the records because many machines have been resold since 1971. If the total number of die-casting machines in use is 10,000 to 15,000 (estimate based on an average annual production of 500 machines and an assumed average ownership of 6 to 10 machines per company), only 5 to

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*Letter from Mr. W. R. Johnson (General Motors Corporation) to EPA dated Ausgust 7, 1978.

**Oral testimony of Hugh Thomas (Outboard Marine Corporation) at the hearings on the PCB Ban Regulations, August 25, 1978.

***Oral testimony by William Sharp (Society of Die Casting Engineers) at the hearings on the PCB Ban Regulations, August 25, 1978.

Figure 10.1-1

Calculation of Number of Die-Casting Machines that Used PCB Based Hydraulic Fluids

Total sales of PCB hydraulic fluid, 1970-1971	13,500,000	pounds PCBs
÷ Number of years	2	
= Annual sales of PCB hydraulic fluid	6,750,000	pounds per year
÷ Weight of fluid per gal	11.5	pounds per gal
= Gallons PCBs per year	587,000	gallons per year
x Assumed fraction purchasing companies owning die-casting machines	x .8	
= Gallons PCBs purchased by companies owning die-casting machines	470,000	
x Assumed: 60% used in die-casting machines as makeup fluid	x .6	
= Gallons per year used as makeup fluid	282,000	
÷ Assumed: 400 gallons per year per die-casting machine required as makeup fluid	÷ 400	
= Number of die-casting machines using PCB based hydraulic fluid	704	

7% of the machines presently in service ever used PCB based hydraulic fluid. However, many of the other machines may presently be contaminated with PCBs because of the practice of reclaiming hydraulic fluid.

Other hydraulic systems: General Motors reported use of PCB based hydraulic fluids in systems ranging from 50 gallons to 4000 gallons, with most of the systems being in the 300 gallon range.* Comments submitted by Armco, Inc., (dated August 3, 1978) summarized the results of testing 50 heat transfer and hydraulic systems with an average capacity of 422 gallons. This is reasonably consistent with an average hydraulic system capacity of 350 gallons. It implies that perhaps 1,000 other hydraulic systems used PCB based fluids in the years 1970-71, assuming these systems require proportionately as much hydraulic fluid for makeup as do die-casting machines. These systems were probably owned by all of the companies having die-casting machines plus perhaps an additional 100 steel companies.

Total PCBs presently in use: Total capacity of all of the hydraulic systems that at one time used PCB based hydraulic fluids may be (700 die-casting machines x 400 gallons per machine + 1000 other systems x 350 gallons per system =) 630,000 gallons. GM reported that 80% of their die casting systems have PCB concentrations below 500 ppm*; Outboard Marine reported that recent spot checks of their machine show PCB levels around 100 ppm, compared to a range of 210 to 1400 ppm in 1976 and 1977**. It is therefore likely that the average concentration of PCBs in hydraulic fluid is between 100 ppm and 500 ppm if the single group of die casting machines known to contain 50% PCB fluid is excluded as a special case. If the average density of the presently used hydraulic fluid is ten pounds per gallon, the total amount of PCBs in use in hydraulic systems may be (630,000 gallons x 10 lb per gallon x 100 ppm to 500 ppm PCBs =) 630 to 3150 pounds of PCBs.

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*Letter from W. R. Johnson (General Motors Corporation) to EPA dated August 7, 1978.

**Letter from Hugh Thomas (Outboard Marine Corporation) to EPA dated August 3, 1978.

10.2 Requirements of the PCB Ban Regulation

Continued use of hydraulic systems contaminated with PCBs in excess of 50 ppm is authorized until January 1, 1984, subject to the following requirements:

- Testing: Required for all machines that ever contained a PCB based hydraulic fluid by July 1, 1979, and at least annually thereafter as well as three months after each refilling performed to reduce the concentration of PCBs to below 50 ppm.
- Marking: Hydraulic systems containing liquids contaminated with over 50 ppm PCBs must have the special PCB label applied.
- Retrofill: Retrofilling or topping off with a hydraulic fluid containing less than 50 ppm PCBs is required within 6 months after any test which shows that the concentration of PCBs exceeds 50 ppm.
- Disposal of contaminated fluid: Hydraulic fluid containing over 50 ppm PCBs must be disposed of by incineration in special approved PCB incinerators or by incineration in other facilities such as high efficiency boilers approved by the EPA Regional Administrators. This material can also go to Chemical Waste Landfills or high efficiency boilers if it is between 50 and 500 ppm.
- Storage: Special storage facilities required for the storage for reuse or processing of hydraulic fluid contaminated with more than 50 ppm PCBs.
- Disposal of contaminated machine after liquid is drained for incineration: Essentially not regulated (either salvage or disposal as non-hazardous waste allowed) provided the fluid is first drained from the machine and, if the fluid contained over 1000 ppm PCBs, the hydraulic system is flushed with clean solvent.
- Reclaiming of contaminated hydraulic fluid: Hydraulic fluid contaminated with more than 50 ppm PCBs may be reclaimed for reuse in the owner's hydraulic systems only if it is treated to reduce the concentration of PCBs to below 50 ppm. Reclaiming for purposes of resale is banned unless this activity is exempted by the EPA.

10.3 Cost Impacts of the PCB Ban Regulation

Testing: Most of the hydraulic systems that once used PCB based fluids have since been refilled with fluids based on phosphate esters. Analysis of phosphate esters for the presence of PCBs requires a rather time consuming treatment of the sample and extraction of the PCBs before injecting the prepared sample into a gas chromatograph. In their written comment dated August 3, 1978, to the EPA on the proposed PCB Ban Regulations, Armco Inc., stated that their average cost to analyze hydraulic fluid for PCBs "...is probably closer to $200 than the Versar estimate of $300, once the GC equipment is set up to specifically analyze for PCBs. Laboratories which would only occasionally analyze such samples would probably incur costs exceeding $300 per sample." Only seven of the 50 systems checked by Armco contained PCBs in excess of 1000 ppm.

Identification of all systems that contained PCB hydraulic fluids will require the analysis of the fluid in many systems which might have contained PCBs. As many as 2500 die-casting machines (Versar, 1978, p. 75) and perhaps as many other hydraulic systems might have to be tested to identify the approximately 1700 systems which used PCB fluid and to evaluate the extent of contamination from the use of reclaimed fluid. The cost of the required sampling and analysis program will include sampling and administrative costs of perhaps $20 per system in addition to the laboratory costs of perhaps $250. Costs for the analysis program required by July 1, 1979, might total (1700 to 5000 systems x $270 per sample =) $460,000 to $1,350,000. Since the average PCB concentration is probably in the range of 100 to 500 ppm, most of the systems will have to be retrofilled within six months and tested again within the next year. A second retrofill and another test might be required. Total testing costs could easily exceed $1,000,000.

Since the concentration of PCBs will continually decrease in the hydraulic systems because of retrofilling, leakage, and replacement of the fluid, it is expected that the concentration of PCBs in almost all systems will have decreased to less than 50 ppm by the end of the five years authorized for continued use of contaminated system, and that the testing requirements would not apply to the systems after that time.

Retrofill: Based on the experience reported by GM and Armco, it is expected that most of the systems that ever used PCB based hydraulic fluid will be found to be contaminated at levels exceeding 50 ppm. If this is the case, retrofilling will be required for perhaps 1700 hydraulic systems having an average capacity of about 400 gallons. Armco stated that the Versar estimate of $14 per gallon for retrofilling was reasonable;* GM estimated the material cost alone to be $17 to $19 per gallon;** Outboard Marine estimated a cost of $8,000 for a 350 gallon system, or an average of $23 per gallon.*** Total costs of the first retrofilling program would be (175 systems x 400 gallons per system x $14 to $23 per gallon =) $9,800,000 to $16,100,000. According to data presented by both Armco and GM, such a retrofilling program might be expected to reduce the concentration of PCBs in the liquid by about 90%. Perhaps 10% of these systems might have PCBs in excess of 50 ppm after being retrofilled, so a second retrofill, and in a few cases even a third retrofill, would be required. Total costs for these subsequent retrofills might be $1,000,000 to $1,500,000.

Topping off systems with PCB concentrations only slightly above 50 ppm may result in lowering PCBs levels below 50 ppm without incurring the costs of draining and refilling the entire system.

Disposal of contaminated fluid: Special high temperature incineration of liquids contaminated with PCBs in excess of 500 ppm was required by the PCB Disposal and Marking Regulations. The effect of the PCB Ban Regulations is to extend this requirement to fluids containing between 50 and 500 ppm PCBs. The most recent available price for this incineration is $55 per 55 gallon drum (Rollins, 1978) plus drum costs of perhaps $15 per drum, transportation of $.02 per pound, and drum disposal costs of $30, or a total cost of $.22 per pound for contaminated hydraulic fluid. If all of the fluid in the calculated system capacity of 630,000 gallons required special disposal because of this change in the regulation, increased disposal costs of (630,000 gallons x 10 lb per gallon x $.22 per pound =) $1.4 million would be incurred. If the use of contaminated reclaimed fluid has resulted in an increased number of systems contaminated with PCBs in excess of 50 ppm, this disposal cost might increase by a factor of 2 or 3 or more. The required retrofilling will generate a quantity of liquid equal to the calculated system capacity, resulting in an additional disposal cost of $1.4 million.

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*Armco, Inc. "Main Comments," received by EPA August 3, 1978.

**Letter from W. R. Johnson (General Motors Corporation) to EPA dated August 7;, 1978.

***Letter from Hugh Thomas (Outboard Marine Corporation) to EPA dated August 3, 1978.

The regulations authorize the EPA Regional Administrators to approve alternative incineration facilities for liquids such as contaminated hydraulic fluids. It is possible that approval for the use of high efficiency boilers might lower the disposal costs substantially, but no estimate can be made of the resulting decreases in disposal costs.

Marking: The requirement that the special PCB label be applied to systems found to contain from 50 to 500 ppm PCBs should not cost more than $2 per machine. Even if (as an upper bound estimate) 2500 such contaminated systems were found, total labeling costs would not exceed $5,000.

All of the liquid that is removed from the hydraulic systems during the retrofill and decontamination activities will also have to be placed in labeled containers prior to being shipped for disposal. At a cost of $2 per 55-gallon drum, labeling costs for disposal could total (630,000 gallons x 2/55 gallons per drum x $2 per label =) $46,000.

Special storage areas: Liquids contaminated with 50 to 500 ppm PCBs will be allowed to be stored in drums in temporary storage areas prior to disposal if a Spill Prevention, Control and Countermeasure Plan has been prepared for the temporary storage area in accordance with 40 CFR 112.

There is no information available in the record that would support an estimate of the number of additional SPCC plans that would have to be prepared under this requirement. However, it is assumed that perhaps one third of the 585 firms that bought PCB hydraulic fluid during the period 1970-1971 will be found to have contaminated hydraulic systems and that some of the 200 firms will therefore have to prepare SPCC plans covering temporary storage areas for PCB contaminated liquid.

Disposal of contaminated machines: It is not anticipated that any of the machines will be scrapped before they are decontaminated to a level below 50 ppm PCBs. Therefore, there should be no additional disposal costs due to the PCB Ban Regulations.

Recycling of contaminated hydraulic fluid: New phosphate ester based hydraulic fluid costs about $7.60 per gallon (Versar 1978, p. 68). According to the comments of GM, the following treatment techniques have been found to be incapable of reducing the concentration of PCBs to below 50 ppm: PAC carbon filter, Florsil filter column, and clay. Open air distillation of contaminated phosphate ester fluid resulted in excess oxidation of the fluid. Outboard Marine has described a vacuum distillation procedure which reduces the PCB content of the hydraulic fluid by 50% at a cost of $3.75 to $4.00 per gallon*. Mr. Rober Damiani of RADCO Industries in his oral comments at the August 25, 1978 hearings, described in general terms a fractional distillation process that is "effective in removing PCB. In fact, a number of runs were made in which PCB concentration was reduced to below 50 ppm." Mr. Damiani stated that RADCO has not developed a process that will reliably reduce the level of PCBs to below 50 ppm and that their present process achieves a reduction to 100 ppm. He stated that the result of a 50 ppm requirement will be to "decrease process yield, and subsequent economics -- 10 to 20 percent below that expected with a 100 ppm specification."

If it is assumed that the total amount of contaminated fluid is available for recycling once per year and that there is presently 725,000 gallons of such fluid in service, the successful development of a reclaiming process might reduce costs for new fluid by $2.80 per gallon (based on reclamation costs 20% higher than mentioned by Outboard Marine Corp.) or by a total of $350,000 to $1,700,000 per year. It is not known whether the requirement that recycled fluid contain less than 50 ppm PCBs will significantly affect the availabilty of such a reclamation service; the total impact of the regulation therefore cannot be estimated.

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*Oral testimony by Hugh Thomas (Outboard Marine Corp.) at the August 25, 1978 hearings on the proposed PCB Ban Regulation.

10.4 PCBs Controlled by the Regulation

In section 10.1, it was estimated that hydraulic systems contaminated with more than 50 ppm PCBs may contain from 630 to 3150 pounds of PCBs. If the use of these systems were not regulated, all of this material would be expected to leak out of the systems and eventually enter the environment. The requirement that the contaminated systems be retrofilled by the end of 1979 will reduce total losses to leaks prior to the retrofilling. Since hydraulic systems often require make-up fluid equal to their volume each year, the losses of PCBs prior to the retrofilling may equal 25% of the PCBs present in the systems. The effect of the regulation, therefore, is to prevent the loss to the environment of .75 x (630 to 3150 lbs =) 470 to 2390 pounds of PCB.

10.5 Summary - Economic Impacts

Testing:

1979	$460,000 to 1,350,000
1980-1984	$1,000,000 total

Retrofill:	$10,800,000 to $17,600,000*
Disposal of fluid:	$1,400,000*, **
Marking:	$46,000
Special storage areas of SPCC plans:	Insufficient data available to estimate
Ban on recycling contaminated hydraulic fluid:	Insufficient data available to estimate. Maximum possible impact = $350,000 to $1,700,000 per year for one or two years.

10.6 Cost Per Pound of PCBs Kept from the Environment

Cost per pound = ($460,000 to $1,350,000 + $1 million +
$10.8 to $17.6 million + $1.4 million +
$700,000 to $3.4 million)/470 to 2390 pounds =
$6,000 to $53,000 per pound PCBs

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*May be significantly higher if the use of reclaimed hydraulic fluids has contaminated hydraulic systems that never used PCB based fluids.

**May be somewhat reduced if EPA approves alternative incinerators for hydraulic fluids.

11.0 HEAT TRANSFER SYSTEMS

11.1 Present Use of PCBs in Heat Transfer Systems

In his letter to the EPA dated August 4, 1978, Mr. W.R. Corey of Monsanto estimated that there were 450 heat transfer systems using PCB based fluid in 1972 when Monsanto discontinued sales of PCBs for those systems. A review of a Monsanto customer list, however, indicated that sales of PCB heat transfer fluids were made to 533 different companies during the years 1970 and 1971 (Versar, 1978, p. 76). Mr. Corey estimated that one half of the heat transfer systems had capacities between 50 and 500 gallons and that the other half had capacities averaging 2000 gallons. This implies that the average system capacity was 1300 gallons, or about 15,000 pounds of PCB. The total Monsanto sales of heat transfer liquid during 1970 and 1971 was 8.2 million pounds, or enough liquid to fill about 550 average systems. Total use of PCB heat transfer liquid in the United States since 1929 has been estimated at 21 million pounds, including both new installations and makeup fluid (Versar, 1978, p. 75).

Mr. Corey of Monsanto estimated that over 90% of the heat transfer systems using PCBs were converted to alternative non-PCB fluids in 1970-72 and that current system PCB levels in the industry range from around 100 ppm to three percent. Mr. Jack Pulley of Dow Corning, in his reply comment dated October 9, 1978, stated that Dow Corning replaced PCB fluids in their heat transfer systems about five years ago and that these systems still contain PCBs in concentrations from 1/2% to about 2% in the new non-PCB heat transfer fluid. Data is also available for one other heat transfer system that contained 14,000 gallons of PCB based fluid. Draining and flushing prior to replacement of the liquid reportedly reduced the concentration of PCBs to two percent (Versar 1978, p. 76). Monsanto and Dow Corning agreed that it is technically infeasible to reduce the concentration of PCBs in contaminated systems to below 50 ppm.

11.2 Requirements of the PCB Ban Regulation

All heat transfer systems that ever used PCB based fluids will be considered PCB articles because their surfaces are presently in contact with a liquid containing over 50 ppm PCBs. These systems will be allowed to remain in service until July 1, 1984, subject to the following conditions:

- Use: After October 1, 1979, no heat transfer system containing a liquid with a PCB concentration above 50 ppm may be used in the manufacture or processing of any food, drug, or cosmetic.
- Testing: Required by July 1, 1979, for all heat transfer systems that ever contained a PCB based heat transfer fluid. Systems must be retested within three months after each time the fluid is replaced to reduce the concentration of PCBs to below 50 ppm. Records of all tests must be kept for five years after the concentration of PCBs is reduced to 50 ppm.
- Retrofill: Within six months following any test that indicates the presence of more than 50 ppm PCBs in heat transfer fluid, the fluid must be drained and replaced with fluid that contains less than 50 ppm PCBs. Topping off that results in reduction of PCB concentration to less than 50 ppm is also allowed.
- Marking: Required for all systems found to have PCB concentrations in the fluid in excess of 50 ppm.
- Disposal of liquid containing over 50 ppm PCBs: For liquids with greater than 500 ppm PCBs, incineration is required in an approved PCB incinerator. Liquids between 50 and 500 ppm PCBs can go to approved high efficiency boilers or chemical waste landfills.
- Storage: Special storage facilities required for the storage of PCB contaminated heat transfer fluid.
- Disposal of contaminated machine after liquid is drained: High temperature incineration required in an approved PCB incinerator or disposal of machine in an approved chemical waste landfill.

11.3 Cost Impacts of the PCB Ban Regulation

Testing: The liquids used to replace the PCB based heat transfer liquids may be analyzed for PCBs by a method similar to that used to analyze for PCBs in transformer oil. The cost of such an analysis should be about the same as the price of $60 per sample previously quoted by Versar for the transformer oil analysis (Versar 1978, p. 41). Sampling and order handling costs might increase this cost to $100 per sample, or a total of $45,000 to $60,000 for the analysis required by July 1, 1979, on the 450 to 600 contaminated systems presently in use. Additional testing required within three months of each system retrofill is included below as part of the retrofill costs.

Retrofill: The regulations require that the concentration of PCBs in heat transfer systems be reduced to less than 50 ppm by July 1, 1984. Most of the systems now contain about two percent PCBs. Monsanto stated that draining most heat transfer systems will remove at least 90% of the fluid, and that new replacement heat transfer liquid will cost about $8 per gallon.* Disposal of contaminated fluid containing over 500 ppm PCBs in an approved PCB incinerator would cost from $1.20 per gallon (in tank truck lots) to $2.10 per gallon (in 55 gallon drums) (Rollins, 1978). Transportation would add about $.02 per pound or $.16 per gallon to this cost (Versar, 1978). Since one-half of the systems have capacities of over 2000 gallons, 80% of the liquid may be in these large systems which would generate truckload lots of fluid when drained. The average disposal cost would therefore be $1.54 per gallon, including transportation. Incineration costs for liquids contaminated with less than 500 ppm PCBs were quoted at about one-half the rate for the more contaminated liquids (Rollins, 1978). This would be equal to a cost of $.81 per gallon, including $.02 per pound transportation. If each system were drained every six months of 90% of the fluid and then refilled with new fluid that did not contain PCBs, any PCBs that were adsorbed on the vessel walls or absorbed into porous gasket material would have a chance to diffuse into the liquid between retrofills. Each draining would therefore remove 90% of the PCBs from the system, progressively reducing the concentration from the present 20,000 ppm (2%) to 2,000 ppm, then to 200 ppm, and finally to 20 ppm after the third retrofill. If the average system capacity is 1,300 gallons, the 450 to 600 contaminated systems presently contain (1300 x 450 to 600 gallons =) 585,000 to 780,000 gallons. The cost to reduce the concentration of PCBs from the present 2% to below 50 ppm will be $15 million to $20 million as calculated in Table 11.3-1.

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*Letter from W. R. Corey (Monsanto) to EPA dated August 4, 1978.

Since each system must be analyzed within three months after each retrofilling, a total of (450 to 600 x 3 =) 1350 to 1800 additional analyses will be required at a cost of $100 each, for a total additional analytical cost of $135,000 to $180,000.

Marking: The marking of heat transfer systems containing liquids contaminated at levels above 500 ppm PCBs is required by the Disposal and Marking Regulations (EPA, 1978a). Since no systems are expected to be contaminated at levels between 50 ppm to 500 ppm, the change in the definition of PCB mixture from 500 ppm to 50 ppm in the Ban Regulation is not expected to change the number of heat transfer systems requiring the application of a special label.

The drums and trucks used to transport the contaminated liquid to the incinerator for disposal will also require special labeling. Since this is already required for liquids containing over 500 ppm PCBs, the effect of the Ban Regulation will be to add this requirement to the disposal of the liquid from the third retrofill. If four labels are required per machine @ $2, total additional labeling costs will be (450 to 600 machines x 4 labels x $2 per label installed =) $3600 to $4800.

Storage for Disposal: Since the required disposal areas will have to be installed at each location that uses contaminated heat transfer systems to meet the requirements of the Disposal and Marking Regulations, no additional cost will result from the PCB Ban Regulations.

Disposal of Heat Transfer Systems: There is no information in the record that will support any estimate of the number of heat transfer systems that will be scrapped before they are decontaminated to PCB levels below 50 ppm.

Table 11.3-1

Cost of Retrofilling Heat Transfer Systems
to Meet 50 ppm Limit on PCB Concentration

Number of contaminated systems	450-600
x Average System Capacity	1,300 gallons
= Total quantity of fluid	585,000 to 780,000 gallons
x Weight per gallon	8 lbs per gallon
x Concentration of PCBs	2% PCBs
= Pounds of PCBs in fluid	93,600 to 124,800 lbs PCBs
First Retrofill	
Total quantity of liquid	585,000 to 780,000 gallons
x Drainage efficiency	.9
= Gallons to be disposed of and replaced	526,500 to 702,000 gallons
PCB Content @ 2%	84,200 to 112,300 lbs PCBs
Cost of replacement fluid @$8.00/gal	$4,212,000 to $5,616,000
+ Cost of disposal @ $1.54/gal	$810,800 to $1,081,000
+ Labor @ 16 hours/system @ $15/hour	$108,000 to $144,000
= Total cost of first retrofill	$5,130,000 to $6,840,000
Second Retrofill	
PCB content @ 2000 ppm	8,420 lbs to 11,230 lbs PCBs
Total cost of second retrofill	$5,130,000 to $6,840,000

Table 11.3-1 (Continued)

Third Retrofill

PCB content @ 200 ppm	842 lb to 1,123 lbs PCBs
Cost of replacement and labor	$4,320,000 to $5,760,000
+ Cost of disposal @ $.81/gal	$426,000 to $569,000
= Total cost of third retrofill	$4,746,000 to $6,329,000
Total cost to reach 50 ppm	$15,000,000 to $20,000,000
Total lbs PCBs removed	93,500 lb to 124,700 lbs PCBs

However, since disposal of machines containing fluid with more than 500 ppm PCBs was required by the Disposal and Marking Regulations, the Ban Regulations only affect the disposal of those machines contaminated at levels between 50 ppm and 500 ppm.

The previously established requirement that all heat transfer systems contaminated at levels above 500 ppm be disposed of in approved chemical waste landfills would have resulted in significant costs.

As a very rough estimate, the volume of each system using heat transfer fluid might be ten times the volume of the fluid which it contains. The total volume of material requiring disposal in approved landfills might then be (450 to 600 systems x 1300 gallons/system x 10 gallons system volume/liquid volume 7.43 gallons/cubic foot =) 800,000 to 1,000,000 cubic feet at a cost of $3 per cubic foot (Versar 1977, pp. 2-13). Because of the uncertainty in this estimate, actual disposal cost might be considerably higher than this figure. All of these costs would have been incurred, under the requirements of the Disposal and Marking Regulations which defined PCB mixtures as those containing over 500 ppm PCBs. The effect of the required decontamination will be to decrease the eventual disposal costs by $2.4 million to $3 million.

11.4 PCBs Controlled by the Regulation

Monsanto claimed that leakage from heat transfer systems was infrequent and would seldom exceed 5% of the capacity of the system in any single incident. If retrofilling contaminated heat transfer systems were not required, as much as 10% of the PCBs presently in the systems would be spilled or leaked because of pump seal leaks and accidents. The remaining amounts of PCBs would be incinerated as required by the Disposal and Marking Regulations. If spill cleanup were 80% effective, the effect of the regulation would be to reduce the amount of PCBs entering the environment to 2% of the 93,600 to 124,800 pounds presently in the machines, or by 1872 to 2496 pounds.

11.5 Summary - Economic Impacts

Testing:	
Initial	\$45,000 to \$60,000
Following retrofilling	\$135,000 to \$180,000
Retrofill:	\$15,000,000 to \$20,000,000
Disposal:	
Cost savings because systems are decontaminated	\$2,400,000 to \$3,000,000
Total	\$12,780,000 to \$17,240,000

11.6 Cost per Pound of PCBs Kept from the Environment

$$\text{Cost per pound} = \frac{\$12{,}780{,}000}{1872\ \text{lbs}} \ \text{to} \ \frac{\$17{,}240{,}000}{2496\ \text{lbs}} = \$6827 \text{ to } \$6907 \text{ per pound PCBs}$$

(average = \$6870/lb)

12.0 COMPRESSORS

Prior to 1972, Monsanto marketed a PCB based lubricant under the trade name Turbinol® 153 for use in turbine type compressors. This liquid was apparently used in a number of natural gas pipeline compressors (Versar 1978, p. 78). Although the liquid was flushed out and replaced with non-PCB fluid in the early 1970s, residual levels of PCBs have been found in at least a few of the machines.*

12.1 Requirements of the PCB Ban Regulation

Compressors containing a liquid contaminated with more than 50 ppm PCBs may be used until May 1, 1980, provided a PCB label is applied to each contaminated machine. These compressors may not be used after January 1, 1980, unless they have been decontaminated to a level below 50 ppm PCBs.

12.2 Impacts of the PCB Ban Regulation

Versar previously estimated that there were perhaps ten compressors that would be affected by the proposed PCB Ban Regulations and stated that Columbia Gas and Texas Eastern had been contacted for additional information on the number of contaminated compressors and the cost and feasibility of decontamination (Versar 1978, p. 78).

In his letter to the EPA of August 4, 1978, Mr. Willard Young of Texas Eastern Transmission Corporation stated that Texas Eastern would be able to reduce the level of PCBs in their compressors to below 50 ppm by the end of 1978 "by another cycle of draining, flushing, and installing new lubricants." He did not include any information on the cost of this procedure or the number of compressors requiring decontamination.

In his letter to the EPA of August 4, 1978, Mr. Robert Welch, Jr., of Columbia Gas System Service Corporation stated that forced shutdown of compressors on January 1, 1979, could have a significant effect on the delivery of natural gas, "depending on the number of units affected." Mr. Welch also stated that the economic impact analysis of the proposed regulations (Versar, 1978) was deficient because the cost of service disruption was not estimated. However, Mr. Welch did not furnish any data on the number of contaminated compressors operated by the industry or by Columbia Gas, nor did he include any information on the difficulty, cost, and time required to decontaminate such compressors. Therefore, it is still not possible to estimate the total economic costs of the regulatory requirements which ban the continued use of contaminated compressors. Since Texas Eastern apparently will be able to meet these requirements, total direct cost of the decontamination program should not exceed the $200,000 previously estimated (Versar 1978, p. 79). The requirement that the decontamination program be completed by the end of 1979 gives the industry time to complete the program during the slack summer season, so there should not be any costs caused by service disruptions.

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*Letter from Willard T. Young (Texas Eastern Transmission Corporation) to EPA dated August 4, 1978.

12.3 PCBs Controlled by the Regulation

There is no information in the record that will support any estimate of the amount of PCBs presently in use in compressors. Therefore, no estimate can be made of the amount that will be controlled by the regulation.

12.4 Summary - Economic Impacts

Decontamination costs -- $200,000

13.0 RECLAIMED OIL*

13.1 Present Status of PCBs in Reclaimed Oil

Approximately 1.3 billion gallons per year of used oil is collected for use as road oil, fuel oil, re-refined hydraulic oil, and re-refined lubricating oil. Much of the waste oil previously used in applications other than automotive lubrication has been contaminated with low levels of PCBs, and dissipative uses of this contaminated oil can introduce PCBs directly into the environment.

A total of 2,376 million gallons of new oil were sold during 1975, the major commercial uses being automotive lubrication (50.8 percent); industrial and aviation lubrication (30.5 percent); and other industrial uses primarily in materials processing (17.4 percent). The amount available for collection and recycle was estimated to be 1,154 million gallons, or 48.6 percent of total sales. Data on U.S. use of new (virgin) refined oil and availability of used oil for recycling are presented for the year 1975 in Table 13.1-1.

Data generated by Recon Systems** for a 12-month period during 1970-71 indicate that, out of a total U.S. production of 2,480 million gallons per year, approximately 901 million gallons, or about 36.3 percent, were actually collected for recycling or use as fuel. An additional 601 million gallons were estimated to be used on roads (application for dust

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*This chapter is adapted from Chapter 13 of Versar, 1978. The EPA promulgated the rules affecting the use of reclaimed oil with essentially no changes from the proposed regulations.

**Weinstein, Norman J., (Recon Systems, Inc.), Waste Oil Recycling and Disposal, EPA-670/2-74-052, Princeton, N.J.: August, 1974 (as cited in Versar, 1978).

Table 13.1-1

New Oil Usage and Waste Oil Availability for Recycling in 1975*

Type of Oil	Outlet or Use	U. S. Sales 1975 (gal x 10^{-6})	Fraction Available** for Recycle	Used Oil Available for Recycling
Automotive Lube Oil	Service Stations	239	.63	150
	Commercial Engine Fleets	225	.50	112
	New Car Dealers	103	.90	93
	Auto Fleet and Other Lube Oil Uses	151	.50	75
	Retail Sales for Commercial Engines	95	.63	60
	Garages, Auto Supply Stores	90	.63	57
	Discount Stores	250	.22	55
	Factory Fills (Auto & Farm Equipment)	54	.90	49
	Subtotals	1,207		651
Industrial & Aviation Lube Oils	Hydraulic & Circulating System Oils	314	.42	132
	Metal Working Oils	145	.70	101
	Aviation & Other	147	.50	73
	Gas Engine Oils	60	.90	54
	Railroad Engine Oils	58	.53	31
	Subtotals	724		391
Other Industrial Oils	Electrical Oils	62	.90	56
	Process Oils	340	.10	34
	Refrigeration Oils	11	.50	6
	Subtotals	413		96
Lube Oils Purchased by U. S. Government		32	.50	16
	GRAND TOTALS	2,376		1,154

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*Weinstein, 1974 (as cited in Versar 1978, p. 81).

**Fraction available for recycling after losses in use and to environment.

control and possibly in asphalt) or as fuel oil; this used oil could conceivably have been collected for recycle so that the maximum amount of oil available for collection, based on the Recon Systems' estimates for 1970-71, may be as much as 60 percent of that produced.

A flow chart showing the distribution and utilization of waste oil in the United States, based on the 1970-71 data of Recon Systems, is presented on Figure 13.1-1. Summary data for disposition and usage from Figure 13.1-1 are as follows:*

Fate of Oil After Primary Use	Percentage of New Oil Production
Used as fuel	41.5
Dissipated to environment and waste disposal	42.3
Applied to roads	12.9
Re-refined lube oil products	3.3
	100.0

The general distribution shown in Figure 13.1-1 is believed to be valid at present, although the magnitudes of the specific flows have fluctuated as prices of virgin lube oil and fuel oil have varied. The value of fuel oil has increased since 1970-71, and virgin lube oil was scarce during the period of the Arab boycott and during a portion of the period of price controls. One result of these factors has been increased use of waste oil as fuel, either by the industrial concern generating the waste oil or by processors.

The primary sources of waste oil available to collectors are service stations and other automotive-related facilities. Industrial and

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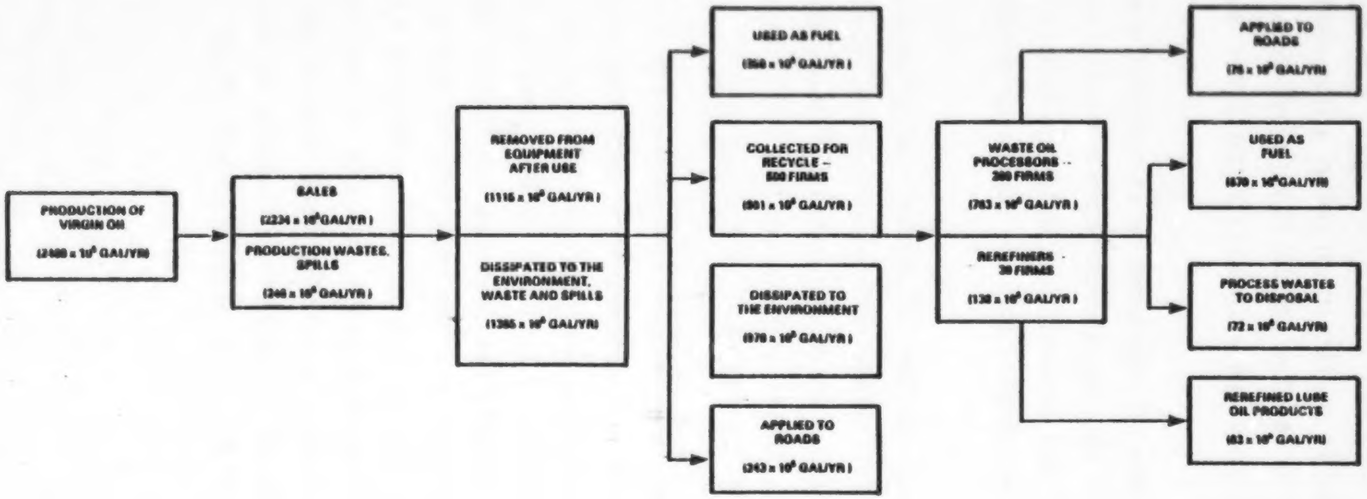
*Versar 1978, p. 83.


PRODUCTION OF VIRGIN OIL
(2480 x 10⁶ GAL/YR)
SALES
(2234 x 10⁶ GAL/YR)
PRODUCTION WASTES, SPILLS
(246 x 10⁶ GAL/YR)
REMOVED FROM EQUIPMENT AFTER USE
(1115 x 10⁶ GAL/YR)
DISSIPATED TO THE ENVIRONMENT, WASTE AND SPILLS
(1365 x 10⁶ GAL/YR)
USED AS FUEL
(350 x 10⁶ GAL/YR)
COLLECTED FOR RECYCLE – 500 FIRMS
(901 x 10⁶ GAL/YR)
DISSIPATED TO THE ENVIRONMENT
(976 x 10⁶ GAL/YR)
APPLIED TO ROADS
(243 x 10⁶ GAL/YR)
WASTE OIL PROCESSORS – 300 FIRMS
(763 x 10⁶ GAL/YR)
REREFINERS – 30 FIRMS
(130 x 10⁶ GAL/YR)
APPLIED TO ROADS
(75 x 10⁶ GAL/YR)
USED AS FUEL
(670 x 10⁶ GAL/YR)
PROCESS WASTES TO DISPOSAL
(72 x 10⁶ GAL/YR)
REREFINED LUBE OIL PRODUCTS
(83 x 10⁶ GAL/YR)

SOURCE: ADAPTED FROM TABLE 26, P. 120 OF WEINSTEIN, 1974 *

FIGURE 13.1-1. DISTRIBUTION AND UTILIZATION OF WASTE OIL IN THE UNITED STATES DURING 1970-71

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*Cited in Versar 1978, p. 82.

aviation facilities are also significant sources. A significantly larger fraction of available oil is collected in urban areas than in suburban or rural areas. According to studies in the Pittsburgh area, spills and other wastes from product pipelines are a locally significant source of waste oil for collection.

The use pattern of processed or re-refined waste oil is extremely diffuse. Users include states and municipalities (road application), industrial and commercial facilities (fuel, re-refined lube oils, road oil), utilities (fuel), and the consuming public (re-refined motor oil).

A small portion of the collection and processing of used hydraulic oils does not follow the general pattern of scattered sources, many reclaimers, and numerous users indicated for the waste lube oils. Reclamation of used hydraulic oil, performed primarily by four companies, results in a product which is marketed as hydraulic oil.

13.2 Requirements of the Proposed Regulations

The disposal of oil contaminated with PCBs in excess of 500 ppm was regulated by the PCB Marking and Disposal Regulations (EPA 1978a). The PCB Ban Regulations change the definition of PCB used in the Marking and Disposal Regulations to include all mixtures containing more than 50 ppm PCBs. Under the provisions of the ban regulations, oil contaminated with PCBs in excess of 50 ppm must be identified, segregated for purposes of disposal, and disposed of in accordance with one of the approved methods. Oil containing measurable amounts of PCBs less than 50 ppm may be processed for any use including fuel or reclaimed lubricating or hydraulic oil, but it may not be used as road oil or as a constituent of any sealant, coating, or dust control agent.

13.3 Sources and Amounts of Contaminated Waste Oil

Hydraulic Fluids: Oil is used as a low viscosity fluid in hydraulic systems, and PCB based hydraulic fluids were widely used prior to 1972. The most expensive (and polluting) use was in die-casting machinery. PCB based hydraulic fluids were also used in construction machinery, farm machinery (a source of feed contamination),* and in deep mining equipment where the use of PCBs resulted in greater fire safety.

Although hydraulic systems are nominally air-tight, leaks may occur at dynamic seals, and major spills may occur due to hose rupture. Normal leakage is collected in drip pans. The rupture of a hose can spray hydraulic fluid over a large area due to high operating pressures. It has been estimated that 80% of phosphate ester hydraulic fluid losses occur from leaks in the hydraulic system.** In certain industries, operators state that it is more efficient to continually add hydraulic fluids to the system rather than shut the system down, repair any leaks and refill the system. Leakage from these systems is often collected and reclaimed.

Monsanto manufactured almost all the PCB-based hydraulic fluids. When Monsanto discontinued manufacturing PCB-based hydraulic fluids in 1971, they did not recommend draining or flushing of hydraulic systems. They did recommend that replacement fluids be added to the remaining PCB fluids in the system. As a result, hydraulic systems which used PCBs in 1972 and prior years now contain replacement fluids contaminated with 0.006 to 50% PCBs as discussed in Chapter 10. The total amount of contamination is a function of the system leakage and dilution during the past five years.

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*U.S. Department of Agriculture Ad Hoc Group on PCBs. Agriculture's Responsibility Concerning Polychlorinated Biphenyls (PCBs) Washington, D.C. Office of Science and Education, U.S. Department of Agricultrue, 1972 (as cited in Versar 1978, p. 84).

**Lapp, T.W. (Midwest Resarch Institute), The Manufacture and Use of Selected Aryl and Alkyl Aryl Phosphate Esters, EPA 560/6-76-008, Feb. 1976, p. 77 (as cited in Versar 1978, p. 84).

A portion of the available used industrial hydraulic oil is refined and sold for reuse as hydraulic oil. This specialized reclaiming service is furnished by the following four companies which reclaim a total of about 150,000 gallons of hydraulic fluid per year (Versar 1978, p. 85).

E. F. Houghton and Co., Philadelphia, Pennsylvania

Radco Corporation, LaFox, Illinois

Findett, Inc., St. Charles, Missouri

Wallover Corp., East Liverpool, Ohio

Automobile and Industrial Lubricating Oil: The amount of used oil collected for reuse in 1970-71 was about 900 million gallons per year, with an additional 600 million gallons used internally for fuel or dust control on roads (Weinstein, 1974). Thus, about 60 percent of the amount of new oil sold was reused. Major uses of this oil were as fuel (1028 million gallons), road oil (319 million gallons), and feedstock for re-refined lubricating oil (138 million gallons) (Versar 1978, p. 85).

The extent of PCB contamination of this oil was studied on a limited basis by the EPA National Enforcement Investigation Center (NEIC) in Denver.* Samples of oil were taken from selected tank truck lots of used oil that had been collected in Virginia, Maryland, and North Carolina. This oil had been delivered to Continental Forest Industries in Hopewell, Virginia, for use as supplemental fuel in a steam boiler of a paper mill. The oil had been collected primarily from automobile service stations, although it is possible that some industrial oil, including hydraulic oil, had been included in some of the lots. PCBs were found in the samples of oil at concentrations ranging from 3.2 ppm to 19.4 ppm. Although these oil samples were collected from a restricted area, the extent of PCB contamination is probably representative of waste oil collected throughout the United States.

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*Testimony of Robert Magruder, (Continental Forest Industries) presented at the U.S. EPA informal hearings on the PCB ban regulations at Washington, D.C., July 15, 1977.

The PCB contamination of the waste oil could come from contaminated industrial hydraulic oil or transformer oil or from PCB additives used in lubricating oils prior to 1973. In applications such as railroad car journal box oils, PCBs may have been used as lubricant additives.* PCBs may also have been added to automobile transmission fluids to control the swelling of oil seals.

It would not be expected that PCBs would be destroyed during re-refining of waste oils. PCBs were reported to be present in concentrations of several parts per million in reclaimed oil used to lubricate whetstones.**

13.4 Compliance Costs

Collection of any waste oil likely to be contaminated with PCBs for a controlled use would not be attractive financially unless the oil were known to contain PCBs at levels below the control amount. Analytical costs for determining low levels of PCBs will be considerably higher than the costs quoted for transformer oil because naturally occurring sulfur and chlorine compounds in petroleum oils cause interferences in the use of electron capture gas chromatography at concentrations of 5 ppm PCBs or below.*** These interferences result in false positive indications of the presence of PCBs. The PCB components can only be resolved through complex clean-up procedures or the use of gas chromatography/mass spectrometry, techniques that would cost up to several hundred dollars per sample.

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*Monsanto Chemical Company, Aroclors for ---, St. Louis, Mo.: undated (as cited in Versar 1978).

**Weems, George, (United States Department of Interior, Denver, Colorado), "Polychlorinated Biphenyls," File HLS 3-3-10h, June 13, 1977 (as cited in Versar 1978).

***Hofstader, R. A. (Exxon Research and Engineering Co.); Lisk, D. J., Bache, C. A. (Cornell University), "Interference in the Electron-Capture Technique for Determination of Polychlorinated Biphenyls by Sulfur-Containing Compounds in Petroleum Products", Bulletin of Environmental Contamination and Toxicology, Vol. 11, No. 2, 1974 (as cited in Versar 1978).

Road Oiling: The most recent data indicates that road oiling consumes 319 million gallons of waste oil per year (Figure 13.1-1). At an application rate of 1/2 gallon per square yard, this is sufficient to oil 45,000 miles of roadway 24 feet wide (Versar, 1978, p. 87). The proposed ban regulations would forbid the use of oil containing detectable amounts of PCBs for dust control. Fluids from transformers are likely to have detectable amounts and other industrial sources are at least somewhat suspect. Currently these industrial oils are collected along with used motor oil. Although virgin motor oil has no PCBs, used motor oil may have PCBs from previous recycling which included industrial oil sources among the feedstocks or from old transmission oils which contained PCBs as an additive. Nevertheless, used motor oil unmixed with industrial sources is unlikely to contain as much as 10 ppm PCBs and may have PCB concentrations that are undetectable without unusually elaborate and expensive analysis. None of the reported analyses of waste oil for PCBs was based on used motor oil without any possibility of industrial contamination. Presumably waste oil solely from automotive sources would contain fewer PCBs. It is doubtful that road oiling could stand the costs of even "simple" tests at $70 per sample. Prospective road oilers therefore would be safer using waste oil if they take precautions to ensure that it does not contain industrial oils (and certainly no electrical oils).

Compliance with the requirements of the proposed regulations could be achieved by either of the following strategies:

(1) Avoid all waste oil, and substitute virgin oil at considerable monetary and energy cost where the customer is willing to pay the increased price. At an average price of $.375 per gallon for #2 fuel

oil vs $.08 per gallon collection costs for used crank case oil, the cost of road oiling would increase (.375 - .08) x 139 million gallons = $94 million per year (Versar 1978, p. 87).

(2) Use synthetic road stabilization chemicals which both reduce dust and provide surface stabilization. The increased cost of this type of material is presently offset by lower road maintenance costs on heavily traveled dirt roads at mines and other industrial facilities. Savings in maintenance on lightly traveled roads would be less significant and would only partially offset the increased material costs. A typical synthetic material is Coherex®, manufactured by Witco Chemical Corporation. This material is an organic resin in a water emulsion which is sold in large quantities for $.40/gallon plus transportation, and is applied after a 5 to 1 water dilution at a rate of one gallon per square yard.* Increased costs incurred by the use of this material are summarized in Table 13.4-1.

The use of synthetic road oiling materials such as Coherex® may be more or less expensive than the use of used motor oil depending on the local supply and price of the used oil. The present choice between the use of used oil and synthetic materials apparently depends on local supply and cost conditions. The total cost resulting from an effective ban on the use of waste oil would certainly be no greater than $31.7 million per year, as calculated in Table 13.4-1, and might even result in an overall cost savings as claimed by Witco Chemical.

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*Letter from Victor Shepard (Witco Chemical Corp.) to EPA dated September 23, 1978.

Table 13.4-1

Cost of Substituting COHEREX® for Used Motor Oil in Road Oiling for Dust Control

Coherex®: Bulk Purchase Price	\$.40/gal.
Transportation @.02/lb. (Versar 1977)	.17/gal.
TOTAL	\$.57/gal.
Material Cost for Coherex®: 1/6 gal./yd^2	.09
Minus: Used Oil: 1/2 gal./yd.^{2} @.08 to .30/gal.*	.04 to .15
Equals: Increased Cost (Savings) per sq. yd.	\$.05 (.06)
x 14080 yd^2 per mile of road, 24 ft. wide =	\$704 (845)
x 45,000 miles =	\$31,680,000/year (\$38,025,000/year)

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*Price range reported by Victor Shepard (Witco Chemical Corp.) for supplies of used oil. Letter to EPA dated September 23, 1978.

Users Other than Road Oilers: About 27 million gallons per year of transformer oil will not be available to collectors. However, oil diverted from road oiling may more than offset this loss of supply. Other industrial oils may or may not be contaminated with PCBs; to be absolutely safe, the recycling industry would avoid them. Individual industrial firms can probably continue to use their own waste oil as fuel oil if they make initial and occasional later spot check laboratory analyses to make sure their oils continue to contain less than 50 ppm PCBs.

The impact on re-refiners (who make re-refined lube oil) and external processors (who process waste oil for use as fuel oil) will depend on what happens to road oiling. A strict enforcement policy with occasional all-out efforts to find PCBs in waste oil could prevent its use as road oil. Diversion of waste oil from this use would create a large increase in supply for processors and re-refiners. Probably most of this would originally go to fuel oil use since the capacity of re-refiners is limited and the consumer acceptance of used motor oil is limited. Later, a majority of the increase might go to re-refiners if the Frost and Sullivan market projections of 23 percent growth per year until 1985 proves to be even roughly accurate.* This would provide an extra use as lube oil while retaining most of the heat value for later use.

Collectors: If collectors avoid transformer and industrial oils, their total business will decrease. However, hauling contaminated oils to chemical waste incinerators or high efficiency boilers will be required and could offer new market opportunities to the collectors.

Processors: Waste oil for fuel use should become more plentiful as use for road oiling is discouraged or made impossible by the regulation. The effect of a larger supply of waste oil on the price to processors theoretically would be to lower the price. Waste oil can be used as a supplemental fuel with coal. This use recovers the fuel value of the oil and would destroy any PCBs that might be present in the oil. Since PCB contaminated oils may be incinerated in large boilers, and since the use of waste oil with coal in boilers is relatively troublefree, this use is probably very elastic. If coal burning plants can absorb the increased supply, which seems likely, the price decrease should be negligible.

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*Maugh, T. W., "Re-refined Oil: An Option That Saves Oil, Minimizes Pollution," Science, p. 1108-1110, September 17, 1976 (as cited in Versar 1978, p. 89).

Hydraulic Oil Re-refiners: Information collected through telephone interviews indicates that at least three of the companies which re-refine hydraulic fluid receive hydraulic fluids which are contaminated with PCBs. These fluids are sometimes contaminated to the extent of 6000 ppm (Chapter 10). In most cases, the reclaiming process removes no more than 10% of these PCBs.* It is also reported that the concentration of PCBs in some of the hydraulic fluid applications encountered by these companies remains at approximately 2000 ppm despite repeated flushings and drainings. The present status of PCB reduction technology is discussed in Chapter 10.

Industrial Waste Oil Generators: Those industries whose waste oil contains more than 50 ppm PCBs will have to incur disposal costs of up to $.75 per gallon (see Chapter 6). Even industrial oil contaminated with less than 50 ppm PCBs may be avoided by waste oil collectors. This may not be a major problem for companies that have large high efficiency boilers. Oil burning boilers can use a mixture of waste and virgin oil. Mr. Magruder of Continental Forest Industries indicated that up to 14 percent waste oil mixed with #6 residual oil is feasible.** The result may be the development of a separate market for industrial oil with low levels of PCBs for use as fuel. Long term economic impacts should not be significant.

13.5 PCBs Controlled by the Regulation

The provision of the regulation that prohibits the use of oil containing any measurable amounts of PCBs as a coating or dust control agent will affect only those waste oils that contain less than 50 ppm PCBs, since the disposal of the more highly contaminated oils is controlled by other provisions of the regulation. The only available data indicate that waste oils are presently contaminated with PCBs to levels of 3.2 to 19.4 ppm (section 13.3). No information is available as to the sources of the oils for which this data was obtained, and diversion of transformer oil and contaminated industrial oils to high efficiency boilers might significantly reduce the concentration of PCBs in the remaining waste oil. However, if it is assumed that all of the oil affected by this provision of the regulation is contaminated at levels of 11 ppm (average of 3 ppm and 19 ppm), then the PCB content of the used oil that is available for recycling will be (11 ppm x 8 pounds per gallon x (651 million gallons automotive oil + 54 million gallons gas engine oils + 31 million gallons railroad engine oils + 16 million gallons U. S. government lube oils*) =) 66,176 pounds.

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*Telephone conversion, Dwain Fowkes (RADCO Corp.) with L. Fourt (Versar), September 19, 1977 (as cited in Versar 1978, p. 90).

**Testimony on Robert Magruder (Continental Forest Industries). Presented at the U.S.E.P.A. informal hearings on the PCB Ban Regulations at Washington, D. C., July 15, 1977.

Approximately 12.9% of new lubricating and industrial oil production has been applied to roads, 41.5% used as fuel, and 3.3% re-refined as lube oil. Diversion of the 12.9% that has been used on roads will control (.129 x 66,176 pounds PCBs =) 8537 pounds of PCBs. If this oil is used as fuel and re-refined as lube oil products in the same ratio as above, (41.5/(41.5+3.3) =) 93% will be used as fuel and 7% will be re-refined. About one half of the re-refined oil will be lost to the environment and the other half will be used as fuel, so the effect of the regulation will be to divert about 96.5% of the 8537 pounds per year of PCBs used on roads to fuel use. Since many of the boilers using this oil may not meet the criteria established for high efficiency boilers, perhaps 2% of the PCBs in the waste oil will not be destroyed. Therefore, the total amount of PCBs that will be destroyed in the boilers rather than applied to roads will be (8537 pounds PCB per year x .965 diverted to fuel use x .98 destruction efficiency =) 8073 pounds PCBs per year. The actual amount diverted to the environment may be lower if the controls on the disposal of transformer oils and contaminated industrial oils decreases the amount of PCBs in the remaining waste oil.

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*Table 13.1-1.

13.6 Summary - Economic Impacts

Compliance Costs

Road Oil - increased costs of virgin or synthetic material (first several years)	$0 to 31.7 million/year
Road Oil - increased cost of obtaining adequate supplies of segregated used motor oil after level of PCBs in used motor oil drops below detectable limits.	$0 to $6.4 million/year

13.7 Cost Per Pound of PCBs Kept from the Environment

Cost per pound =

$$\frac{0 \text{ to } \$31.7 \text{ million per year}}{8073 \text{ pounds/year}} =$$

0 to $3925 per pound PCBs

14.0 PCBS AS UNINTENTIONAL PRODUCT CONTAMINANTS

14.1 Current Production

There are a number of commercial chemical processes which produce PCBs as an unintentional byproduct in concentrations over 50 ppm. These include the production of two classes of pigments, a new aluminum smelting process, and several other proprietary chemical processes.

Phthalocyanine pigments: Phthalocyanine blue and green pigments are produced in two steps.* The first step is the production of crude pigment using, in most cases, trichlorobenzene as a solvent.* In this instance, a side reaction involving the trichlorobenzene is the source of the PCBs. The crude is then further processed to produce a number of different blue and green pigments. In 1976, production and imports of phthalocyanine blue and green pigments were 13,200,000 lbs* with a value of roughly $87.6 million. Testing indicates that the majority of this type of pigment is contaminated with over 50 ppm PCBs, though there is considerable doubt concerning the validity of the test method which was used.**

Currently, the only major domestic crude manufacturer which does not use trichlorobenzene as a solvent is DuPont.*** They reportedly use kerosene and have developed pigments based on the properties of the crude they produce. In addition, Phthalchem uses a mixed solvent system which has trichlorobenzene as one of the components. Testing indicates that this crude may be contaminated below 50 ppm; again, however, the analytical method has not been validated.

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*"Main Comments of Dry Color Manufacturers Association ...." dated August 7, 1978, p. 16.

**Testimony of the Dry Color Manufacturers Association at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C. August 30, 1978.

***Oral testimony of Arthur Hopmeier, (Phthalchem Inc.), at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978.

Imports of blue crude, primarily from Japan, supplied over 56% of the U.S. market in 1976.* In addition, low-PCB crudes are currently available in commercial quantities from at least one Japanese supplier. This is a recent development, and any increase in demand for this product could not be met for roughly a year.** Also, Mr. MacDonald Smith of Sun Chemical testified that this low PCB crude was of inferior quality.***

Diarylide pigments: Diarylide yellow, orange, and red pigments are made by reaction of precursors which include dichlorobenzidine as an essential component. A minor side reaction results in the decomposition of the dichlorobenzidine to produce 3,3'- dichlorobiphenyl.****

Sales of diarylide pigments in 1976 were about 9,760,000 pounds with a value of $41 million.**** There are currently no substitutes for the diarylide pigments, which are used in printing ink, textile ink, plastics, and paints. In 1969, diarylide yellow (the diarylide with by far the highest production) accounted for 84% of all yellow pigments produced in the United States.****

Aluminum smelting: Alcoa has developed a new smelting process which inadvertently produces over 50 ppm of decachlorobiphenyl.***** The PCBs are produced in a preliminary step involving the production of aluminum chloride through the reaction of alumina with chlorine in the presence of coke. The PCBs and other contaminants are removed in the second step, which is the electrolysis of the aluminum chloride to produce metallic aluminum.

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*Oral testimony of Arthur Hopmeier, (Phthalchem Inc.) at the PCB Manufacturing, Processing, Distribution in Commerce and Use Bans Hearings, Washington, D.C., August 30, 1978

**Letter to EPA from W. C. Parle, (Harmon Colors) July 11, 1978.

***Oral comments of Hugh MacDonald Smith (Sun Chemical Corporation) at the PCB Manufacturing, Processing, Distribution in Commerce and Use Bans Hearings, Washington, D.C., August 30, 1978, p.107.

****"Main Comments of Dry Color Manufacturers Association ..." dated August 7, 1978, Table 3.

*****Information on this aluminum smelting process and the resulting PCBs was taken from the letter from James S. Boyt (Alcoa) to EPA dated October 10, 1978.

This process has several advantages over conventional aluminum smelting. These benefits include elimination of fluoride emissions, reduced energy consumption, and improved product purity. The energy savings possible with this process are considerable. Conventional smelting requires 8 KWH per pound of aluminum produced. This new process requires 4.5 KWH per pound, a savings of nearly 44%. Using these figures, a 300,000 ton per year smelter could save up to 1.95 million KWH per year.*

In addition, the production of the aluminum chloride in the above process has a number of energy and process advantages compared to conventional aluminum chloride production methods.

Other chemical processes: Phillips Petroleum and Dow Corning, both have chemical processes that produce over 50 ppm PCBs. The Phillips process is still experimental and apparently involves the use of PCBs as a chemical intermediate.** Dow Corning states that during the production of a chemical intermediate, PCBs, apparently largely monochlorinated biphenyl, are produced at levels between 50 and 500 ppm.*** Tennessee Eastman also had a chemical process that produced over 50 ppm PCBs.**** However, Tennessee Eastman subsequently advised EPA that it had modified its process and "because of these modifications, the only time a concentration of PCB in excess of 50 ppm occurs is after processing to concentrate and dispose of the PCBs, as specifically contemplated at 43FR24805....."*****

Polychlorinated terphenyls (PCTs) formerly produced by Monsanto are known to have been contaminated with over 50 ppm of PCBs. The only uses of PCTs discussed at the hearings were a number of applications in microscopy. This use has been authorized. Similar applications involve the use of certain Aroclors. These uses have also been authorized.

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*Letter to EPA from James S. Boyt (ALCOA) dated October 10, 1978.

**Letter to EPA from Phillips Petroleum Co. dated August 4, 1978.

***Letter to EPA from Jack Pulley (Dow Corning Corporation) dated October 10, 1978.

****Letter from J. C. Edwards (Tennessee Eastman Company) to EPA dated August 7, 1978.

*****Letter from Elliott Stern (Tennessee Eastman Company) to EPA dated December 21, 1978. (Letter in record of TSCA Exemption Docket No. 1)

14.2 Requirements of the PCB Ban Regulations

It is assumed here that none of the operations described above qualify as being "in a totally enclosed manner." Therefore, the manufacture, processing, distribution in commerce, and use of any chemical containing over 50 ppm PCBs (including phthalocyanin and diarylide pigments and the products of the Alcoa smelting process) are banned 30 days after the date of promulgation of the PCB Ban Regulation except in those cases specifically exempted by EPA.

14.3 Economic Impact

Pigment Manufacturers: The impact the ban regulations will have on those manufacturers who produce products contaminated with low levels of PCBs will depend on the actions taken by the EPA in response to petitions for exemption from the regulation. For the purposes of this analysis, an upper bound economic impact will be estimated assuming that no exemptions are granted before enforcement of the regulations begins. A lower bound economic impact will be estimated assuming that all exemptions are granted by the EPA. This second assumption also presumes that, where necessary, exemptions for processing and distribution in commerce will be granted. The Interim Procedural Rules for Polychlorinated Biphenyls (PCB's) Ban Exemption (EPA, 1978d)*, state that only petitions from those affected by the manufacturing ban will be considered. Therefore, separate petitions will be required for processing, distribution in commerce, and use exemptions.

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*EPA. 1978d. "Part 750 - Procedures for Rulemaking Under Section 6 of the Toxic Substances Control Act: Interim Procedural Rules for Polychlorinated Biphenyls (PCB's) Ban Exemption." Federal Register, November 1, 1978, pp. 50905-50907.

The processes in use by Dow Corning, Alcoa, and Phillips Petroleum must cease 30 days after the rule is promulgated unless EPA has granted or is considering a petition for exemptions (EPA 1978d). The small amount of economic data available are insufficient to support an estimate of the impact this will have.

Upper Bound Estimate: There are three companies that manufacture crude phthalocyanine blue using trichlorobenzene as a solvent; they are American Cyanamid, Chemtron, and Phthalchem.* Phthalchem uses a mixed solvent system which has trichlorobenzene as one of the components; the others use pure trichlorobenzene. Dupont uses kerosene; Hercules Powder and Thomasett use a dry process. The crude produced by each of these companies may contain over 50 ppm PCBs although Phthalchem pigment has consistently shown less than 50 ppm PCBs.** In the absence of a valid analytical method for determining PCB levels in this material, however, this study will assume that all three companies must modify their processes to comply with the regulations. Kerosene appears to be the most feasible solvent to replace trichlorobenzene. Mr. Arthur Hopmeier of Phthalchem testified that it would require 12 months and cost roughly $250,000 for him to modify his plant.** Mr. Paul Malchick testified that the two Chemtron plants could be converted to the use of kerosene solvent for a total cost of $1,500,000 but that considering the age and condition of Chemtron's equipment, it would be economically sounder for them to spend $5,000,000 to construct a new plant.* They would also attempt to purchase low-PCB crude from Japan in order to meet their needs during the 24-30 months necessary to construct this plant.* Purchase of the required 3 million pounds of crude per year would cost roughly $4.5 million. No data were given by American Cyanamid. Based on (1) a Chemtron estimate of $750,000 to convert each of their aged plants and (2) Mr. Hopmeier's estimate that Phthalchem's plant would require less to convert than other plants,** the cost for American Cyanamid is estimated at $500,000. The total cost for plant conversion is:

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*Letter from Arthur Hopmeier (Phthalchem Inc.) to EPA - August 4, 1978.

**Testimony of Arthur Hopmeier (Phthalchem Inc.) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978.

$250,000 + $1,500,000 + $500,000 = $2,250,000

In addition, Harmon Colors produces either a special crude or further processes purchased crude in trichlorobenzene to produce a phythalocyanine pigment which contains 575 ppm of PCBs. This pigment is used by the automotive industry and its manufacture has been authorized by the State of Michigan. It would cost Harmon Colors roughly $2 million to construct a new plant capable of producing this pigment in an alternative solvent.***

Four companies presented information which indicates that they may be producing diarylide pigment with PCB levels in excess of 50 ppm. They are: (1) Chemtron, (2) Pope, (3) Ridgeway Color and Chemical, and (4) Sun Chemical. It appears that the diarylide pigments could be produced with less than 50 ppm PCBs if some process modifications were made. There are some estimates on the cost of adjusting the manufacturing process to reduce the concentration of PCBs. Mr. Paul Malchick of Chemtron estimated that it would cost $50,000 to modify their manufacturing and, because the process modifications will put them out of compliance with their NPDES permit, an additional $250,000 will be required.* Two other companies estimate their cost for complying with a 50 ppm limit as follows:**

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*Testimony of Paul Malchick (Chemtron) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978.

**Testimony of Arthur Hopmeier (Phthalchem Inc.) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978.

***Letter to EPA from W. C. Parle (Harmon Colors) dated July 11, 1978.

Company	Initial Capital Cost	Increased Annual Operating Expense
1	$750,000	$250,000
2	$200,000	$375,000-500,000

Three of the four companies listed would have an average conversion cost of $333,000. If this average is used as the cost for the fourth company, the total conversion cost could be $1.33 million. Increased operating costs may amount to $345,000 per company.** Although some types of diarylide pigments already contain less than 50 ppm PCBs, one to two years will be required to reduce the level of PCBs to below 50 ppm in all of these pigments.**

The manufacturing cost estimates for both types of pigments include only those costs directly attributable to plant conversion and to increases in operating costs. If the manufacturers are forced to cease production of all pigments that contain over 50 ppm PCBs, there will be additional costs associated with lost production and future loss of customers who convert to substitutes or foreign suppliers. There may also be costs associated with the disposal of contaminated pigments presently in inventory. There is not enough data in the official record to support an estimate of these costs, but the data which are present deserve attention and seem to indicate that these additional costs could substantially exceed the conversion costs.

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*Testimony of Paul Malchick (Chemtron) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978, p. 126.

**Letter to EPA from Donald Morgan, (Dry Color Manufacturers Association) dated August 7, 1978.

In 1976, production and imports of phthalocyanine blue totaled 13,200,000 pounds* with a value, after processing into pigments, of roughly $87.6 million. Imports of blue crude (not pigment), primarily from Japan (85%), supplied over 56% of the U.S. market in 1976.** The majority of the imports are high-PCB crude. Low-PCB crude is being produced in Japan, but an increase in demand could not be met for a year.***

Sales of diarylide pigments in 1976 were 9,760,000 pounds with a value of $41 million. In addition, roughly 275,000 pounds were imported.****

Sales for phthalocyanine and diarylide pigments in 1976 totaled $131 million. Total sales of all organic pigments in 1976 were $261 million, compared with $200 million for inorganic pigments.**** Thus, the two classes of pigments in question account for over 25% of the domestic market.

The percentage of the industry that would be forced to cease production in response to a manufacturing ban is not known, but it is estimated to be closer to 50% than to 10%.***** This implies that up to one quarter of the domestic organic pigment producing industry would have to close down. In addition, a company that can no longer produce yellow and/or blue pigments may lose other portions of its sales because "customers demand a full line of colors."**** The minimum conversion time given at the hearings was 12 months, so in the event an exemption is not granted, domestic manufacturers would be affected for at least 6 months and would not be back to full capacity for 18 months. The potential for substitution of different pigments types and the ease with which production of low- or non-PCB pigment could be expanded are not known, but it does appear that imports could not immediately fill any shortages. However, the available information indicates that extensive ink, dye, and paint reformulation will be required, equipment may require modification or replacement, and printing quality will suffer.

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*Letter to EPA from Arthur Hopmeier (Phthalchem) August 4, 1978.

**Testimony of Arthur Hopmeier at the PCB Manufacturing, Processing, Distribution, and Use Bans Hearings, August 30, 1978.

***Letter to EPA from W. C. Parle (Harmon Colors) July 11, 1978.

****"Main Comments of Dry Color Manufacturers..." dated August 7, 1978.

*****Testimony of Donald Morgan (DCMA) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, August 30, 1978.

There could be additional costs once domestic manufacturers begin producing low- or non-PCB pigments. In those cases where process modification rather than solvent substitution is used, it may be necessary to test each batch of pigment for PCBs as it is produced. Chemtron states that they have made process modifications that reduce the PCB concentration to low apparent levels but that there may be occasional batches with higher concentrations due to mechanical failure or operator error.* In addition to the testing, production of a batch with over 50 ppm would be illegal production which could be subject to a possible fine. The lowering of the permissible limit from 500 tp 50 ppm PCBs would result in the disposal of additional batches of pigment.

Lower bound estimate: The lower bound estimate assumes that the following eight "pigment" companies will individually apply for (and will receive) exemptions:

American Cyanamid
Apollo Colors
Chemtron
Harmon Colors
Phthalchem
Pope
Ridgeway Color and Chemical
Sun Chemical

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*Letter from Paul Malchick (Chemtron) to EPA dated August 3, 1978.

It is also assumed that each company will apply for two exemptions: one for manufacturing and one for processing and distribution in commerce.

Preparation of the required petition and attendance at the hearing may require one man-week per company. Considering that, due to the importance of the issue and the legal aspects involved, much of this work is usually handled by lawyers and higher level company officials, a labor rate of $200/day will be assumed. In addition, total travel expenses of $600 for two people per company will be assumed. The total expense for the eight companies listed using the above figures is $19,200.

If EPA grants the manufacturers an exemption from the "manufacturing," "processing," and "distribution in commerce" bans, the pigment that is manufactured could only be used to formulate inks, etc., if the purchasers were in turn exempted from the "processing" and "distribution in commerce" bans. Further, since the inks will contain PCBs at levels below 50 ppm because of dilution of material containing more than 50 ppm PCBs, all material containing the pigments will have to be labeled as "PCBs," and the users will require exemptions from the "use" ban.

There is no information in the record that suggests whether EPA will consider class action petitions for exemptions, or that would suggest how EPA may handle the labeling problem. Therefore, no estimate can be made of the resulting economic impacts of these provisions of the regulations.

Other chemicals: No information exists in the record to support any estimate of the impact of the ban regulation on companies such as Alcoa and Dow Corning that are inadvertently manufacturing PCBs in chemicals other than dry pigments. These chemical processes will be subject to the same ban provisions or, alternatively, the need to obtain exemptions from the manufacturing, processing, distribution in commerce, and use ban regulations as described above for dry pigments.

14.4 PCBs Controlled by the Regulation

Pigments: Data reported by Sun Chemical Corp. suggests that the average PCB concentration in diarylide pigments is 95 ppm and in phthalocyanine pigments is 170 ppm.*

Total annual sales of the phthalocyanine pigments are 13.2 million pounds of which 56% is imported (most from Japan).** The rest is made in the U. S. by six manufacturers, three of which use trichlorobenzene and presumably have problems with PCB contamination. If the six manufacturers have equal market shares, the total PCBs in the production of the three that use trichlorobenzene would be (13.2 million pounds pigment per year x .44 U.S. market share x .5 share from companies with PCBs in product x 170 ppm PCBs =) 544 pounds PCBs per year.

Total annual sales of dairylide pigments are 9,760,000 pounds, all of which is contaminated with 3,3' - dichlorobiphenyl at an average concentration of 95 ppm. Reduction of this concentration to 50 ppm by required process changes would reduce the amount of PCBs entering the environment by (9,760,000 pounds pigment x (95 ppm - 50 ppm) =) 441 pounds per year.

Other chemicals: No information is available to support any estimate of the total production of PCBs in other chemical processes.

14.5 Summary - Economic Impacts

Upper Bound:

	Conversion Cost	Increased Annual Operating Costs	Additional Costs
Phthalocyanine pigments	$4,250,000	No data	No data
Diarylide pigments	1,330,000	345,000	No data
Aluminum smelting			
Chemical manufacturing	No data	No data	No data

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*Appendix E to "Main Comments of Dry Color Manufacturers Association...." dated August 7, 1978.

**Letter from Arthur Hopmeier (Phthalchem Inc.) to EPA dated August 4, 1978.

Lower Bound:

Exemption applications	$ 25,600		
Aluminum smelting			
Chemical manufacturing	No data	No data	No data

14.6 Cost Per Pound of PCBs Kept from the Environment

Phthalocyanine pigments

$$\frac{\$425{,}000/{*}\text{year}}{544\ \text{pounds/year}} = \$781 \text{ per pound PCBs}$$

Diarylide pigments

$$\frac{\$133{,}000^{*} + \$345{,}000/\text{year}}{441\ \text{pounds/year}} = \$1084 \text{ per pound PCBs}$$

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*Ten dollars as initial expense is equivalent to continuing annual costs of one dollar discounted at 10%.

15.0 SPILL MATERIALS: 50 ppm TO 499 ppm PCBs

The change in the definition of "PCB" from 500 ppm to 50 ppm will require that materials such as dirt that are contaminated with PCBs in this concentration range will have to be picked up and buried in an approved PCB landfill. There is no information in the record that can be used to estimate the total additional volume of material that will be transported to these landfills as the result of this change in the regulation.

Disposal of PCB contaminated material in approved landfills has been reported to cost $3 per cubic foot (Versar 1977, p. 3-7) and transportation to these facilities will cost an additional $2 per cubic foot (Versar 1977, p. 3-19). If the spill material covered by this regulation is assumed to be contaminated with 275 ppm PCBs, the cost of disposal will be ($5 per cubic foot/(100 pounds per cubic foot of dirt x 275 ppm PCBs) =) $182 per pound of PCB. This figure could be lower in some cases if EPA approves alternative disposal methods in response to specific petitions for exemption from this portion of the disposal regulation.

16.0 CAPACITOR MANUFACTURING

16.1 Present Use of PCBs

PCBs were used as the dielectric liquid in almost all paper/foil and film/foil A.C. electric capacitors manufactured prior to 1976. The primary types and uses of PCB capacitors are listed in Table 16.1-1.

Substitutes for PCBs have been developed by the capacitor manufacturers in anticipation of the ban on the manufacture and processing of PCBs. No PCB power factor capacitors were manufactured after late 1977, and there are no PCB capacitors of this type known to remain in manufacturers' inventories (Versar 1978, p. 99). A survey of manufacturers of industrial capacitors indicated that five companies (representing a 54% share of the market in 1976) were planning in mid 1977 to continue using PCBs into 1978 but to discontinue manufacturing PCB capacitors during 1978 (Versar, 1978, p. 103). Two of the manufacturers have provided additional data on their use of PCBs during 1978 and on expected inventories of PCB capacitors. Aerovox (24% market share) planned to stop using PCBs on September 9, 1978, and expected an inventory on October 1 of less than 100,000 PCB capacitors.* Universal Manufacturing Co. (13% market share) has estimated that its inventory of capacitors at the end of 1978 will be approximately 800,000 items which cost about one million dollars to manufacture. In addition, Universal will have an inventory at the end of 1978 of at least 500,000 completed ballasts which cost about $2,500,000 to make.**

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*Letter from Clifford Tuttle (Aerovox Industries, Inc.) to EPA dated August 15, 1978.

**Oral comments of N. Ray Clark (Universal Manufacturing Corporation) at the August 29, 1978 hearing on the proposed PCB Ban Regulation.

Table 16.1-1

Major Types and Uses of PCB Capacitors

Type	Estimate 1976 Sales*	Use*
Power Factor Correction	$54.5 million	Used by electrical utilities in high voltage power distribution systems.
Industrial Capacitors	$94.5 million	
Motor Control		Used as part of large single phase A.C. motors (air conditioners, etc.).
Ballast		Used as a component of ballasts for fluorescent lights and high intensity discharge (i.e., mercury arc and sodium arc) fixtures.
Electronic		As part of the circuitry in some TV sets, microwave ovens, computers, etc.

*Source: Versar, 1978, pp 97-98.

16.2 Requirements of the PCB Ban Regulation

Manufacturing: The regulation bans the manufacture of PCB capacitors.

Distribution in Commerce: PCB capacitors and new equipment containing PCB capacitors may not be sold (i.e., distributed in commerce) after July 1, 1979.

16.3 Cost Impacts of the PCB Ban Regulation

Manufacturing ban: The economic impact analysis of the proposed PCB regulation estimated that non-PCB power factor capacitors would cost 10% to 20% more than PCB capacitors having the same performance characteristics and that the cost of industrial capacitors would increase 15% to 20% because of the change from PCBs to other dielectric fluids, (Versar, 1978). The only additional information that has since become available is the testimony of Ray Clark who suggested that "perhaps in the overall, simply based on the difference of dielectric constant (of the non-PCB dielectric fluid) the non-PCB industrial capacitors should cost more on the order of five to seven percent."* Based on 1976 industry sales (Table 16.1-1), annual cost increases due to the banning of the manufacture of PCB capacitors would be expected to be (10% to 20% of $54.5 million = $5.5 million to $11 million for power factor correction capacitors and (7% to 20% of $94.5 million =) $6.6 million to $18.9 million for industrial capacitors. These estimates should be increased by perhaps 15% to compensate for inflation during 1977 and 1978. Since the use of small capacitors is expected to grow rapidly over the next few years because of federally mandated improvements in the electrical efficiency of appliances, the total demand for capacitors and the total increased costs resulting from the ban on the use of PCBs may be greater than these estimates based on historical sales data.

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*Oral comments of N. Ray Clark (Universal Manufacturing Corporation) at the August 29, 1978 hearings.

Ban on Distribution in Commerce: The demand for PCB capacitors remaining in manufactures's inventories at the end of 1978 is likely to be extremely limited because the regulation bans the sale of these capacitors or new equipment containing PCB capacitors after June 30, 1979. The inventory losses incurred by the companies that use small capacitors in the manufacture of appliances and equipment is discussed in detail in Chapter 3.

The maximum inventory losses incurred by the manufacturers of PCB capacitors would occur if all capacitors remaining in inventory at the end of 1978 were scrapped. If all of the manufacturers who used PCBs in 1978 had the same expected inventory losses as that percentage of annual sales anticipated by Universal, total inventory losses would be (.54 market share for all affected capacitor manufacturers/.13 Universal market share) x $1,000,000 Universal inventory loss =) $4.15 million. However, the actual loss will probably be much less than this because Universal was the last company to phase out the use of PCBs and because some opportunities may exist during the first six months of 1979 to dispose of this inventory. Therefore a reasonable estimate of inventory losses may be in the range of $1 to $2 million, all occuring during 1979.

16.4 PCBs Controlled by the Regulation

Total consumption of PCBs by the capacitor manufacturing industry was 21 million pounds in 1975 of which 45% was used in large high voltage power factor capacitors and 55% in industrial, lighting, and appliance capacitors (Versar 1976a, p. 6).

Most large high voltage power factor capacitors do not rupture upon failure, and only 20% to 25% of the PCBs escape to the environment from those that do rupture. If it is assumed that 10% of the capacitors rupture on failure, the total amount of PCBs entering the environment from each year's production of large high voltage power factor capacitors would be equal to (21 million pounds per year PCBs x 45% in power factor capacitors x 1% rupture on failure x 15% PCBs lost on rupture =) 14,200 pounds PCB per year.

Only 0.4% of the small capacitors are assumed to rupture in use (Chapter 3). If 15% of the PCBs leak out of these ruptured capacitors, the total amount of PCBs entering the environment from each year's production of small capacitors would be equal to (21 million pounds PCBs x 55% in small capacitors x 0.4% ruptured in use x 15% leak out =) 6930 pounds per year. The rest of the PCBs would be disposed of in municipal landfills. There is no information in the record to support an estimate of how much may leach out of the landfill, but it is expected to be low due to the absorptive capacity of the surrounding material.

16.5 Summary - Economic Impacts

Increased cost of non-PCB power factor capacitors: \$5.5 million to \$11 million per year.

Increased cost of non-PCB industrial capacitors: \$6.6 million to \$18.9 million per year.

Inventory losses incurred by manufacturers of PCB industrial capacitors: \$1 million to \$2 million (1979 only).

16.6 Cost Per Pound of PCBs Kept from the Environment

Power factor capacitors

$$\frac{\$5.5 \text{ million to } \$11 \text{ million per year}}{14{,}200 \text{ lb/year}} = \$387 \text{ to } \$775 \text{ per pound PCBs}$$

Industrial capacitors

$$\frac{6 \text{ million to } \$18.9 \text{ million per year}}{6930 \text{ pounds per year}} = \$950 \text{ to } \$2750 \text{ per pound}$$

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17.0 BAN ON THE MANUFACTURE OF NEW PCB TRANSFORMERS*

Liquid filled transformers containing a PCB based liquid known generically as "askarel" have been used for many years in those installations where the risk of fire justified the use of a fire resistant fluid. Askarel transformers have been allowed in hazardous locations such as inside buildings without the requirement for a fireproof vault or fire sprinklers. No substitute transformer liquids have yet been developed which have fire resistant properties equal to the PCB based askarel.

17.1 Requirements of the Regulations

The regulations prohibit the manufacture of new PCB transformers after December 31, 1978, but classify continued use of existing PCB transformers, except those used in railroad locomotives, as use in a totally enclosed manner. The regulations authorize certain minor maintenance of existing transformers but prohibit major rebuilding of failed units. The impacts of the regulation on the servicing and rebuilding of askarel transformers is discussed in detail in Chapter 4. Disposal requirements for failed askarel transformers are specified by the PCB Marking and Disposal Regulations, and these requirements are not being changed by the PCB Ban Regulations.

17.2 Industry Structure, Production, and Sales

Monsanto's customer list for PCBs in the early 1970s included thirteen companies that used PCBs to manufacture askarel transformers. These companies and the location of their transformer manufacturing plants are listed in Table 17.2-1. Production of askarel transformers averaged 5000 units per year in the early 1970s (Versar 1978, p.109). When these companies were contacted by Versar in September, 1977, only one manufacturer was still producing askarel transformers, and it planned to stop production of this type of unit before the end of 1977 (Versar 1978, p.109). All of these manufacturers produced both oil-filled and askarel transformers in the same plants. Oil-filled transformers are interchangeable with askarel transformers in new applications provided the installation is properly engineered. Other substitutes for askarel transformers are also available. The 140,000 askarel transformers presently in service are only two percent of the total number of power and distribution transformers in use (Versar 1978, p.111).

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*This chapter is repeated with minor changes from Versar, 1978. The EPA promulgated without change the proposed regulations that affect the manufacture of new PCB transformers.

17.3 Substitutes for PCB Transformers

The askarel transformers presently in service were specified because this type of liquid-filled transformer offered advantages in size, reliability, and fire safety that were not available with other types of transformers. Alternatives to PCB transformers have always been available, although all of the other types of transformers have different design characteristics and none are direct substitutes for the PCB units. Therefore, eventual replacement of the existing PCB transformers will require that each of the present installations be re-evaluated and that the necessary engineering changes be made to allow use of the best available replacement unit. New transformer installations will be designed to make optium use of the available non-PCBs transformers. The choice among the available alternative transformer types and materials depends on the requirements of each specific applicaiton and the characteristics of the available non-PCB units.

Table 17.2-1

U.S. Transformer Manufacturers That Used PCBs After 1970

Company Name	Plant Location
Westinghouse Electric Corp.	South Boston, Va. Sharon, Pa.
General Electric Company	Rome, Ga. Pittsfield, Mass.
Research-Cottrell	Finderne, N.J.
Niagara Transformer Co.	Buffalo, N.Y.
Standard Transformer Co.	Warren, Ohio Medford, Oregon
Helena Corp.	Helena, Alabama
Hevi-Duty Electric	Goldsboro, N.C.
Kuhlman Electric Co.	Crystal Springs, Mass.
Electro Engineering Works	San Leandro, Calif.
Envirotech Buell	Lebanon, Pa.
R.E. Uptegraff Mfg., Co.	Scottsdale, Pa.
H.K. Porter	Belmont, Calif. Lynchburg, Va.
Van Tran Electric Co.	Vandalia, Ill. Waco, Texas

Source: Versar, 1976a.

A number of alternatives to the use of PCBs in fire resistant liquid-filled transformers and to the use of transformers that contain any dielectric liquid have been developed and are commercially available. These substitutes for PCB transformers differ in their performance characteristics, applicable fire code installation requirements, and cost. The following sections discuss the major types of substitute units that are available.

Non-PCB askarel transformers: Askarels are defined in the National Electrical Code as non-flammable chlorinated hydrocarbon liquids. Although all askarel liquids used in the past have been based on PCBs, there is no requirement that PCBs be present. General Electric is presently testing a non-PCB askarel that is a combination of trichlorobenzene, tetrachlorobenzene, and a hydrocarbon (either isopropyl biphenyl or terphenyl). GE plans to market this material in 1979 under the trade name Iralec®, if present transformer service tests are successful, and estimates that the price will be about one-half that of silicone.*

If Iralec® does prove to be a direct substitute for PCB based askarel, there may be no additional costs incurred by the banning of the use of PCBs in new transformers.

High fire point liquid insulated transformers: The 1975 National Electric Code (NEC) and previous issues allowed only the use of askarel and dry type transformers in hazardous locations without vault protection. Askarel was essentially defined as a PCB based liquid. The 1978 NEC has added a specification (Article 450-23) for "high fire point liquid insulated transformers" which can be used under these same conditions (Versar 1978, p.111). The high fire point liquid must have a fire point of at least 300°C, and must not propagate flames.

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*Information presented by GE at a meeting with EPA Office of Toxic Substances, June 21, 1978.

Underwriters Laboratory presently lists three liquids as meeting the high fire point property requirements for transformers operating at voltages below 600v (Versar 1978, p.112):

Dow Corning 561

General Electric SF-97 (50)

SWS Silicones Corp. F-190

Factory Mutual Research has not yet completed developing formal approval requirements and procedures for high fire point transformer liquids. However, based on preliminary tests, Factory Mutual has issued interim guidelines to its field offices which allow six silicone liquids and three hydrocarbon liquids at Factory Mutual insured locations without special fire protection. The list of Factory Mutual accepted liquids includes the following (Versar 1978, p.112):

Supplier	Designation	Type of Fluid
Dow Corning	DC 561	Silicone
Dow Corning	DC 200	Silicone
General Electric	SF-97	Silicone
Union Carbide	L-305	Silicone
SWS Silicones	F-101	Silicone
SWS Silicones	F-190	Silicone
RTE Corporation	RTEmp	Hydrocarbon
Gulf Oil Chemicals Co.	RF Dielectric Fluid	Hydrocarbon
Uniroyal	PAO-20E	Hydrocarbon

Mineral oil-filled transformers: If fire safety were not a consideration, there would be no reason why oil-filled transformers could not be used in all applications. In the past, PCB-filled transformers have cost about 1.3 times as much as oil-filled units of the same capacity, and thus most users preferred the oil type where possible (Versar 1978, p.112). The oil-filled transformers are the same size as the askarel units and are considerably lighter in weight. Also, mineral oil has somewhat better heat transfer characteristics than askarel, and an electric arc in mineral oil results in breakdown products that are non-corrosive.

The major disadvantage of mineral oil is flammability; transformer mineral oil has a flash point of 145°C. If an arc occurs in the transformer, the breakdown products will be hydrogen and methane, both of which are flammable. Detailed records of such failures are maintained by the electrical industry. Fire Underwriters does not approve of the use of oils and other flammable liquids for indoor applications. Where oil-filled transformers are not specifically prohibited as on-site replacements for PCB-filled units, the National Electrical Code imposes certain restrictions upon their mode of installation.

Oil-filled transformers are used in almost all power transformer applications and for most substation distribution applications where the transmission line high voltage is reduced to 12.8 kv for local distribution. Most rural pole-mounted transformers that reduce the voltage to 220 volts are also oil-filled. The issue of flammability only becomes important where the distribution transformer must be buried, as in many urban applications, or located close to, within, or on the roof of the building it serves. PCB-filled transformers have, in the past, been used in most such applications. Oil-filled transformers can be used in these applications only if they are suitably isolated from flammable structures or if these structures are suitably safeguarded against fires. When transformers are located outside the building they service, the low-voltage power must be brought into the building via cables or insulated buses. Additional energy losses are then caused by heating in the low-voltage transmission lines from the transformer to the point of use.

Open air-cooled transformers: Transformers can be built without the use of a liquid cooling medium. One type of dry transformer that is quite successful, under limited conditions, is the open air-cooled transformer. In this design, cooling air is driven through the transformer by either natural convection or forced circulation. In those sizes where air-cooled transformers are available, they are about equal in price to askarel-filled transformers of the same kVA rating. However, open air-cooled transformers are limited in both heat capacity (which limits their ability to operate under occasional overload conditions) and dielectric strength (which limits the maximum voltage available).

The problem of electrical insulation is even more severe if the open air-cooled transformer only operates intermittently. When the transformer is operating, the heat generated within the windings keeps the insulation dry and maintains a high dielectric strength in the solid insulating material. However, when the transformer is not operating, the coils cool to ambient temperatures and the insulation can absorb moisture from the air which reduces its dielectric strength. Open air-cooled transformers must be thoroughly dried before being put into service after each cool period.

One other problem with air-cooled transformers is the tendency of dust to be attracted from the air to the coils by electrostatic forces. Dust can build up in the coils and block the flow of air, or it can form conductive paths and cause short circuits.

Open air-cooled transformers are generally limited to dry, clean locations where the load requirements are fairly even and constant and where the maximum voltage does not exceed 30 kv. Such transformers are being successfully used in large office buildings, particularly tall buildings where the transformers are located every few floors. Even in this application, though, conditions arise that exceed the capabilities of the transformer. For instance, in the Sears Tower in Chicago, which is over 1400 feet tall, the electric power is brought into the building and up to the distribution transformers at 128 kv, which is beyond the voltage limitations of open air-cooled transformers (Versar 1978, p.115).

Closed gas-filled transformers*: Transformers can be built with dry inert gas (usually at an elevated pressure) as a heat transfer medium. These transformers avoid the maintenance problems caused by moisture and dust in open air-cooled transformers, but they are similarly limited in overload capacity because of reduced thermal inertia compared to liquid-filled transformers.

Closed gas-filled transformers must be installed in pressure-tight containers because of changes in gas pressure caused by changes in temperature. However, the maximum voltage ratings of gas-filled transformers can be equal to these of liquid-filled units.

A number of different gases have been used as heat transfer media in closed gas-filled transformers. The most common gas used in the U.S. is the fluorocarbon hexafluoroethane (C_2F_6). Nitrogen and sulfur hexafluoride have also been used successfully in certain applications. Helium has not been found to be a satisfactory gas for this application because its low dielectric strength results in corona discharges within the transformer. Hydrogen is unsatisfactory because any leak in the transformer would result in a severe fire hazard.

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*This section is repeated from Versar 1978, pp.115-116.

Because of the necessity for a pressure vessel container, gas-cooled transformers are 30 to 40 percent heavier than PCB-filled transformers and cost two-thirds more (and twice as much as oil-filled transformers). In addition, the gas-filled transformers must be sized larger than oil-filled units to allow for the expected heavy load peaks of power consumption.

17.4 Relative Prices of Non-PCB Transformers

The relative prices of distribution transformers of the size and type commonly installed in office buildings are summarized in Table 17.4-1. If the RTEmp® high fire point liquid-filled transformer proves to be acceptable for installation without auxiliary fire protection, there should be no cost increases for new transformer installations resulting from the ban on the manufacture of PCB transformers. The open dry type transformers are also quite cost competitive with the PCB units for most applications.

Table 17.4-1*

Relative Transformer Prices

Type of Unit	Price: 1000 kVA Unit	Price: 2000 kVA Unit
Oil-filled	$15,300	$23,300
PCB	19,900	30,300
Non-PCB askarel	19,000	29,000
RTEmp®	18,400	28,000
Silicone	22,300	34,500
Open air cooled	20,700	35,000
Sealed gas cooled	30,600	46,600

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*Source: MGC Engineers, "Distribution Transformer Status - WTI Project." Memorandum to U.S. General Services Administration, June 1, 1977, as cited in Versar 1978, p.116.

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17.5 Compliance Costs

Clean-up costs: The only costs incurred by transformer manufacturers resulting from the ban on the use of PCBs will be clean-up and disposal costs of flushing PCBs from storage and material handling equipment before using this equipment to store high fire point liquids. This equipment consists primarily of storage tanks, filters, pumps, and piping. Clean-up costs, including disposal of contaminated solvents, should not exceed $10,000 per plant, or a total one time cost impact of perhaps $100,000 in 1977 and 1978 (Versar 1978, p.117).

Cost of substitutes: The high fire point liquid cooled transformers and air-cooled transformers will cost about the same to 10% more than askarel units depending on the acceptability of non-PCB askarels and hydrocarbon base high fire point transformer liquids. Based on past sales of 5000 askarel units per year at an average price of $20,000, a 10% cost increase would increase sales and costs to the users by (5000 x $20,000 x 10% =) $10,000,000 per year. There should be no effect on the demand for transformers for new installations, and there may be an increase in the demand for replacement transformers of 1000 to 2000 units per year. This additional demand should be easily supplied since the transformer manufacturing industry has recently been operating at only about 60% of capacity (Versar 1978, p.117).

Market structure should not be significantly affected because all of the former manufacturers of askarel transformers will have equal access to the high fire point transformer liquid materials and technology. Access to this market segment will open to those transformer manufcturers who did not offer askarel as an alternative to oil. This will primarily afford a marketing opportunity to RTE Corporation which has never supplied askarel units but which has a strong market position in the high fire point liquid transformer area. The increased sales by RTE will probably be less than the total increase in transformer sales, so this small shift in market structure should not result in a net decrease in the sales by any of the other manufacturers.

Increased fire losses: The presently installed PCB askarel transformers were installed at a premium cost compared to oil-filled units in order to achieve improved fire safety. Not all of the substitutes for PCBs have as good fire resistance. In particular, the high fire point transformer liquids can burn under certain conditions, including exposure to an external fire, and can release flammable gases if an electrical arc occurs within the transformer.

Various non-flammable substitutes for PCB askarel transformers are available, including the various dry type units and non-PCB askarels. Although these alternatives may cost more than the PCB units they replace, they can achieve equal fire safety. Therefore, the banning of the manufacture of PCB-filled transformers is not expected to result in significant increased fire losses.

17.6 PCBs Controlled by the Regulation

There is no information in the record to support any estimate of the probability that PCBs used in askarel transformers will enter the environment from accidental spills and venting of transformers. Venting results in the loss of no more than 2% of the total fluid in the transformer. However, good clean-up of spills should limit the total losses to perhaps 5% of the total liquid vented. Use of PCBs in transformer manufacturing was about 12 million pounds per year in 1975 (Versar 1976a, p.6). The ban on use of PCBs in new transformers will prevent the loss of (2% x 5% x 12 million pounds =) 12,000 pounds of PCBs into the environment from each year's production of transformers.

17.7 Summary - Economic Impacts

Transitional Costs:

Clean-up costs for manufacturers	$100,000 1978 only.

Long Term Costs:

Higher costs of non-PCB transformers	$0 to $10 million per year.

17.8 Cost Per Pound of PCBs Kept From the Environment

$$\text{Cost per pound} = \frac{\$0 \text{ to } \$10 \text{ million per year}}{12{,}000 \text{ pounds per year}} =$$

$0 to $833 per pound PCBs

18.0 SUMMARY

18.1 Transitional Cost Impacts

Costs of decontaminating or scrapping existing equipment and the ban on rebuilding of PCB transformers are all transitional costs. These costs will end when the existing PCBs are finally removed from service. The transitional cost impacts identified in this analysis of the impacts of the PCB Ban Regulation (as distinct from the previously promulgated PCB Effluent Standard and the PCB Disposal and Marking Regulations) are summarized in Table 18.1-1.

18.2 Long Term Cost Impacts

The costs resulting from the ban on the manufacture of PCBs will be continuing costs and will result in along term economic impact. These costs include the additional cost of non-PCB capacitors and transformers. The long term costs identified as resulting from the PCB Ban Regulation are summarized in Table 18.2-1.

18.3 Cost Per Pound of PCBs Kept from the Environment

The effectiveness of the regulation in preventing the entry of PCBs into the environment was calculated for each industrial segment if sufficient data was available. These costs are summarized in Table 18.3-1.

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Table 18.1-1

Transitional Cost Impacts

Item (Chapter)	$ Million Per Year 1979	 Succeeding Years	$ Million Total	Estimated Reliability of Total
PCB Transformers:				
Manufacturer Clean Up Costs (17)	$ .1	0	$ .1	-50% + 500%
Ban on Rebuilding (4)	9.6	**	373 to 749	±50%
Lost Service Time	2.4	**	75	±50%
Locomotive Transformers (5)				
Retrofill Program to 6% Limit	Complete by Jan. 1, 1982		6.6	±20%
Retrofill Program to 0.1% Limit	Complete by Jan. 1, 1984		5.15	±20%
Analytical Costs	Complete by Jan. 1, 1985		.444	±50%
PCB Capacitors and Equipment				
Equipment Redesign (16)	*			
Manufacturers' Inventory Obsolescence (16)	1 to 2	0	1 to 2	±50%
Ban on Sales of Equipment after July 1, 1979 (3)	1,000	0	1,000	-100% + 50%
	These costs will be significantly reduced or eliminated if EPA grants exemptions from the "distribution in commerce" ban.			
Cost of Petitioning for Exemptions	10***	0	10	

*Data not available to support estimate; probably small cost impact.

**Costs will be incurred over 30 to 40 years, probably increasing slowly for 10 years and then decreasing slowly.

***May be significantly reduced if EPA accepts class action petitions.

Table 18.1-1 (Continued)

Item (Chapter)	$ million Per Year 1979	$ million Per Year Suceeding Yrs	$ million total	Estimated Reliability of Total
Oil Filled Transformers (6)				
Ban on Reclaiming Oil for Resale	3.2 to 5.6	3.2 to 5.6	? No data on duration of impact	
Cost of Equipping High Efficiency Boiler	No data	0		
Cost of Approved PCB Incineration	0 - 11.1	0 - 11.1	? No data on duration of impact	-90% to 0%
Transformer Service (7)				
Special Storage Areas	*	*	?No data on duration of impact	
Mining Machines (8)				
Rebuild Loaders	Complete by Dec 31, 1981		1.6	±20%
Scrap Continuous Miners	Complete by Dec 31, 1981		1 to 2.6	±50%
Storage Costs	.01	0	.01	±50%
Exemption of Application	.001	0	.001	±50%
Electromagnets (9)				
Ban on Rebuilding	.1	.1	.96	±20%
Hydraulic Systems (10)				
Testing	.5 to 1.4	1(1980-84 total)	1.5 to 2.4	±20%
Retrofill	9.8-16.1	1-1.5(1980 only)	10.8 to 17.6 by 1984	±50%
Disposal of Fluid 50-500 ppm PCBs	1.4	.2(1980 only)	1.6	-80% + 20%
Marking	.05	0	.05	±50%
Ban on Recycling Fluid	.3 to 1.7	0 to 1.7	.7 to 3.4	-80% + 20%

*Information Not Available in Record to Make Estimate.

Table 18.1-1 (Continued)

Item (Chapter)	$ million Per Year 1979	$ million Per Year Succeeding Yrs	$ million total	Estimated Reliability of Total
Heat Transfer Systems (11)				
Testing	.045 to .06	.135 to .18	.18 to .24	±50%
Retrofill	5.1 to 6.8	9.9 to 13.2 (1980 only)	15 to 20 (by 1980)	±50%
Cost Savings - Disposal of Systems			(2.4 to 3.0)	±50%
Compressors (12)	.2	0	.2	-50% + 100%
Reclaimed Oil (13)				
Increased Cost of Synthetic Road Oil Material	0 to 31.7	0 to 31.7 (thru 1984)	0 to 100	
Increased Cost of Road Oil		0 to 6.4 (years 6-15)	0 to 64*	
Unintentional Contaminants (14)				
Process Changes - Phthalocyanine Pigments	4.25	0	4.25	-80% + 50%
Process Changes - Diarylide Yellow Pigments	1.3	0***	1.3***	-80% + 50%
Process Changes - Other Processes	**	0	**	
Exemption Applications	.02	0	.02	-80% + 50%

*Costs to continue indefinitely until waste industrial oil no longer contains measurable amounts of PCBs.
**Information not available in the record to make estimate.
***Also long term cost impacts: See Table 18.2-1.

Table 18.2-1

Long Term Cost Impacts

Transformers: (Chapter 17)	
Increased Cost of Non-PCB Transformers	$0 to 10 million/year
Increased Fire Losses	$0
Capacitors: (Chapter 16)	
Increased Cost of Non-PCB Power Factor Capacitors	$5.5 to 11 million/year
Increased Cost of Non-PCB Industrial Capacitors	$6.6 to 18.9 million/year
Diarylide Yellow Pigment (Chapter 14)	
Increased Manufacturing Cost	$345,000/year
Spill Materials (50 to 500 ppm PCBs) (Chapter 15)	No data

Table 18.3-1 Economic Costs of the PCB Ban Regulation

Chapter Number	Item	Total Cost $ Million	Pounds PCBs Diverted from the Environment	Cost per Pound of PCBs
3	Scrap Spare PCB Capacitors	1	500	$ 2,000
3	Remove PCB Capacitors from Equipment in Inventory	1,000	5,360	$187,000
		These costs will be significantly reduced or eliminated if EPA grants exemptions from the "distribution in commerce" ban.		
4	Ban Rebuilding Askarel Transformers	397 to 771 (30 yrs)	47,000 to 925,000	$429 to $16,400
5	Retrofill Railroad Transformers to 6%	6.7	**(3.76 million lb) total	**(>$1.75)
5	Retrofill Railroad Transformers from 6% to .1%	5.15	**(80,240 lb. total)	**(>$68)
6	Require Incineration of Transformer Oil	96 to 510 (30 yrs)	200,000	$480 to $2,550
7	Special Storage Areas at Transformer Service Stops	*	*	*
8	Retrofill/Ban PCB Miner Motors	2.6 to 4.3	? (27,500 lb total)	? (>$94 to $155)
9	Ban Rebuilding Electromagnets	.96	200 to 2,000	$480 to $4,800

*Information not available in record to make estimate.

**Figure represents total amount of PCBs in this use. Information not available in record to make an estimate of amount diverted from the environment.

Table 18.3-1 (Continued)

Chapter Number	Item	Total Cost $ Million	Pounds PCBs Diverted from the Environment	Cost per Pound of PCBS
10	Decontaminate Hydraulic Systems	21.4 to 25	470 to 2,390	$6,000 to $53,000
11	Decontaminate Heat Transfer Systems	12.8 to 17.2	1,872 to 2,496	$6,870
12	Decontaminate Compressors	.2	*	*
13	Ban Use of Waste Oil on Roads	0 to 31.7/year	8,073/year	$0 to $3,925
14	Phthalocyanine Blue Pigments	.425/year	544/year	$781
14	Diarylide Yellow Pigments	.478/year	441/year	$1,084
15	Spill Materials (50-500ppm)-to Chemical Waste Landfill	*	*	$182
16	Ban New Large PCB Capacitors	5.5 to 11/year	14,200	$387 to $775
16	Ban New Small PCB Capacitors	6.6 to 18.9/year	6,930/year	$950 to $2,730
17	Ban New PCB Transformers	0 to 10/year	12,000/year	$0 to $833

*Information not available in the record to make estimate.

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